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Does pregnancy make women more cautious and calm? The impact of pregnancy on risk decision-making

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Abstract

During pregnancy, a variety of psychological and physical changes occur in women, which may have different impacts on risk decision-making involving different processes systems. Based on the dual-process theories of decision-making, using the Columbia Card Task (CCT) as the experimental paradigm, which can trigger deliberative versus affective decision-makings respectively, this study recruited 240 pregnant women and non-pregnant women aged 20-40 as the experimental group and control group respectively, investigated how pregnancy impacted on women's risk decision-making, as well as the possible roles played by a series of psychological factors (impulsivity; sensation seeking; emotional state) and physiological factors (gestational age; human Chorionic Gonadotropin, hCG; progesterone) in the above process. The results were as follows: (a) Compared with non-pregnant women, pregnant women tended to choose fewer cards, indicating a higher risk aversion consistent with a more conservative strategy, both in cold and hot CCTs; in both cold and hot CCTs, compared with pregnant women in the second trimester of pregnancy, pregnant women in the first and the third trimesters of pregnancy had a higher risk aversion tendency. (b) Pregnant women had lower levels of all dimensions of sensation seeking than did non-pregnant women, pregnant women in the third trimester of pregnancy had lower levels of Disinhibition (DIS) and Boredom Susceptibility (BS) of sensation seeking than pregnant women in the first and the second trimesters of pregnancy, but there was no significant difference in levels of emotional state or impulsivity between pregnant woman and non-pregnant women. (c) DIS of sensation seeking played a fully mediating role in the impact of pregnancy on hot CCT performance. (d) Both hCG and progesterone levels were negatively correlated with pregnant women's hot CCT performances. (e) Positive emotion played a partial mediating role in the effect of progesterone on hot CCT performance of pregnant women.

Keywords: pregnancy, risk decision-making, sensation seeking, emotional state, progesterone

1 Introduction

For women, pregnancy is a major life event causing many psychological and physical changes, which may have different impacts on risk decision-makings involving different processes systems. On the psychological aspect, pregnancy may lead to changes in women's impulsivity, sensation seeking, and emotional state. Impulsivity and sensation seeking are considered two favorable predictors of risk-taking behaviors (Dunlop & Romer, 2010; Johansson, Grant, Kim, Odlaug & Gotestam, 2009); and the two are closely related to the deliberative processes system versus the affective processes system respectively (Hu, Zhen, Yu, Zhang & Zhang, 2017). Moreover, positive and negative emotions can also affect risk decision-making (Chuang & Lin, 2007; Kuhnen & Kmitson, 2011). On the physiological side, changes of gestational age, human Chorionic Gonadotropin (hCG) and progesterone are significant characteristics that may have psychological effects. Based on the above changes, pregnant women and

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non-pregnant women may show different decision-making behaviors in risk decision-making tasks involving different processes systems.

1.1 Pregnancy and Risk Decision-making

Risk decision-making refers to the choice made after weighing the options with multiple outcomes and stated probabilities of their occurrence (Kahneman & Tversky, 1979). Certain strong motivators or goals are likely to affect the processing of risk information, with such factors more closely linked to reproduction, survival, or evolution likely to have a more profound impact on such decision-making (Bugental, 2000), and pregnancy is one of these factors. Pregnant females of all species exhibit behavioral changes during pregnancy (Kinsley & Lambert, 2008). Pregnancy may lead to major changes in psychological states (such as changes in social roles) and physiological states (such as changes in hormones), which may further trigger cognitive and emotional changes in women and ultimately affect their decision-making.

Psychologically, the impact of pregnancy on women's risk decision-making is likely to be achieved through three factors: impulsivity, sensation seeking, and emotional state. New mothers not only need to adapt to the new demands presented by their offspring, but also to face the risk of energy loss and a failure of gene investment (Kinsley & Lambert, 2006). Pregnant women who are unable to adapt to new demands in high-risk situations are likely to lose some valuable genetic investment, and only those who can adapt to changes and meet with physiological and environmental needs can ensure the survival of their offspring and preserve genetic inheritance (Lambert & Kinsley, 2012). According to the Theory of Maternal Role Attainment (Rubin, 1967), before pregnant women acquire new skills to cope with new challenges, their maternal identity will continue to increase (Mercer, 2004). The social change of roles leads pregnant women to think about their future lives and about future events in detail, in what some have termed as a "maternal mind" that is conducive to the continuation of future generations and to genetic inheritance; this may further influence their decision-making (Li, Peng & Xiong, 2015; Li, Wang, Sun, Xiong & Yang, 2018). This "maternal mind" may reduce women's impulsivity and sensation seeking levels during pregnancy, so that they can better cope with risk changes. And impulsivity and sensation seeking are considered two valid and strong predictors of risk-taking behaviors in various real risky domains (Dunlop & Romer, 2010; Johansson et al., 2009). Previous studies have shown that individuals with higher scores on the impulsivity trait would make more risky decisions (Penolazzi, Gremigni & Russo, 2012); individuals with higher scores on the sensation seeking trait were more likely to engage in thrill-seeking activities or risky health-related behaviors (Arria, Calderia, Vincent, O'Grady & Wish, 2008; Stephenson & Southwell, 2006); sensation seeking and its subscales were also correlated with the Domain-Specific Risk Taking Scale and its subscales (Khodarahimi, 2015). In addition, impulsivity and sensation seeking are related to the Dual-process Theory (Hu et al., 2017); impulsivity is thought to come from the poor performance of the deliberative processes system, while sensation seeking is thought to stem from the sensitivity of the affective processes system to affective cues (Harden & Tucker-Drob, 2011; Quinn & Harden, 2013; Steinberg et al., 2008). Thus it is likely that impulsivity and sensation seeking paly different roles in the process of pregnancy affecting risk decision-makings which involve the deliberative processes system versus affective processes system. In addition, previous studies have found that first-time mothers may experience more positive than negative emotions (Harwood, McLean & Durkin, 2007); and emotion can also affect risk decision-making (Chuang & Lin, 2007; Kuhnen & Kmitson, 2011). Therefore, pregnant women's emotional state may affect their risk decision-making.

Physiologically, the impact of pregnancy on women's risk decision-making is likely to be related to gestational age and hormone changes. The "gestational age" (i.e. the duration of pregnancy which be calculated from the first day of a woman's last menstrual period, and totally about 40 weeks) derived from pregnancy may be a factor that has a greater impact on women's decision-making. The result of a meta-analysis showed that gestational age was an effective predictor of the level of maternal-fetal relationship (Yarcheski, Mahon, Yarcheski, Hanks & Cannella, 2008). As the gestational age increases, the degree of the maternal-fetal relationship gradually rises and peaks in the third trimester of pregnancy (Rowe, Fisher & Quinlivan, 2009). In addition, changes in hormones associated with pregnancy are also likely to lead to changes in decision-making behavior. The increase of estrogen and progesterone might cause female mammals exhibit all sorts of maternal behaviors (Kinsley & Lambert, 2008). Moreover, the impulsive choice for cocaine can reduced by progesterone in female rats (Smethells, Swalve, Eberly & Carroll, 2016); there is a positive association between testosterone level and risk-seeking behavior (Apicella, Dreber & Mollerstrom, 2014; Sapienza, Zingales & Maestripieri, 2009); sex hormone-cortisol ratios modulate risk-taking behavior differentially in men and women (Barel, Shahrabani & Tzischinsky, 2017).

The level of hCG gradually increases during pregnancy. It will stimulate further secretion of progesterone and increase the level of progesterone. As a hormone interacting with multiple brain regions, progesterone levels were related to the incidence of depression (Fan et al., 2009) in pregnant women; and progesterone has desirable effects for mood stabilizing, anxiolytic, antidepressant and sedation, which can improve the emotional well-being and quality of life of individuals (Cagnacci, Arangino, Baldassari, Alessandrini &

Volpe, 2004; Siddle, Fraser, Whitehead, Jesinger & Pryse-Davies, 1991). Progesterone has even been used to treat postnatal depression (Soltau & Taylor, 1982); clinically, doctors attribute positive or negative emotional and mental states to various pathways of progesterone metabolism (Bitzer, 2010); and the change of positive and negative emotions also affect risk decision-making of individuals (Chuang & Lin, 2007; Kuhnen & Kmitson, 2011). Therefore, hormonal changes during pregnancy are likely to affect women's risk decision-making by affecting their emotional state.

1.2 Dual-process Theories and Risk Decision-making Task

In the process of human development, risk-taking behavior may originate from biological, social, cognitive and emotional mechanisms (Casey, Jones & Hare, 2008). According to the dual-process theories of decision-making, there are two systems interacting in the process of decision-making, namely, the deliberative processes system versus the affective processes system (Evans, 2008; Kahneman & Frederick, 2002). The former is purposive, analytic, and controllable; it requires more psychological resources, and is slower; individuals who rely on this system tend to make deliberate decisions. The latter is preconscious, automatic, and associative; it affects behavior through emotion; it does not require much psychological resources, and it is more rapid; individuals who rely on this system tend to make decisions based on intuition and emotion.

Since pregnancy will bring significant psychological and physical changes in women, and these changes and their resulting changes in cognition, personality, and emotion may affect women's decision-making; so, pregnancy is likely to affect women's risk decision-making through both the deliberative and affective systems. In order to fully investigate the research problem of this study from both deliberative and affective aspects, we used the Columbia Card Task (CCT). The CCT contains two subtasks: cold CCT and hot CCT, which involving the deliberative and affective systems, respectively (Figner, Mackinlay, Wilkening & Weber, 2009). The two CCT versions were designed to imitate two typical everyday-life decision-making situations, one is making a decision in a calm mode, and the other is making a more affect-charged decision. Compared with other dynamic or non-dynamic risk decision-making tasks, the CCT has two useful characteristics: first, it assesses not only risk decision-making tendency but also the complexity of the decision makers' information use and determines which of three factors that should be affecting risk decision-making have been taken into account (outcome probability, gain amount, and loss amount); second, the two versions can differentially trigger deliberative versus affective decision-making processes. Some studies found that the hot CCT did indeed trigger activity in the affective system (e.g., Shohamy et al., 2004); participants' self-reports about their own decision-making strategies (either affect-based or deliberative) and their emotional arousal during decision making have amply demonstrated the specific involvement of the deliberative versus affective processes systems in the cold and hot CCT (Figner et al., 2009).

1.3 The Present Study

Based on the above reviews and analysis of the current literature, this study also set out to explore the impacts of pregnancy on women's risk decision-making by comparing the different behaviors of pregnant and non-pregnant women in risk decision-making involving the deliberative and affective processes systems, and at the same time to explore the possible roles of psychological factors (impulsivity, sensation seeking, emotional state) and physiological factors (gestational age, hCG, progesterone) in the above process. This study tested the following hypotheses: (a) compared with non-pregnant peers, pregnant women have a higher risk aversion tendency; (b) the risk decision-making tendencies of women of different gestational ages are different; (c) the risk decision-making behavior of pregnant women is predicted by their impulsivity, sensation seeking, emotional state, gestational age, hCG, and progesterone; (d) impulsivity, sensation seeking and emotional state may play some roles between the pregnant or not and CCT performance; (e) emotional state may play a mediating role in the effects of hCG and progesterone on hot CCT performance among pregnant women.

2 Method

2.1 Participants

120 healthy pregnant women (primiparas) aged 20-40 years old (M_{age} = 26.70, SD = 4.19; non-students) who have set up health records in a public hospital obstetrics department in Chengdu city of Sichuan province in China for regular examinations were recruited voluntarily as the pregnancy group; and according to the characteristics of fetal development and following modern clinical science rules, the gestational age was divided into three categories: the first trimester (4 < gestational week $\leq 12^{+6}$, n = 40), the second trimester (13-27^{+6} gestational weeks, n = 42) and the third trimester (gestational week $\geq$ 28, n = 38) (Cao, 2014).[1] 120 non-pregnant women (nulliparae) aged 20-40 years old (M_{age} = 25.46, SD = 4.71; non-students) were recruited from several communities in the city as the control group. All the participants were from families of different socioeconomic status, and were in good physical and mental health. They had never participated

[1] 12^{+6} and 27^{+6} represent gestational ages of 12 weeks + 6 days and 27 weeks + 6 days, respectively.

TABLE 1: Details regarding the participants(N=240).

Demography Variable		Age(M±SD)	Proportion(%)
Participant Type	the First Trimester(n=40)	26.65±5.04	16.67
	the Second Trimester (n=42)	26.31±3.60	17.50
	the Third Trimester (n=38)	27.18±3.86	15.83
	Non-pregnancy (n=120)	25.46±4.71	50.00
Age	20-29 (n=186)	24.10±2.46	77.50
	30-40 (n=54)	32.91±2.92	22.50
Education Level	High School or Below (n=82)	26.51±4.56	34.17
	Junior College (n=69)	25.49±3.81	28.75
	Bachelor Degree or Above (n=89)	26.13±4.90	37.08

in similar studies. See Table 1 for details regarding these participants.

2.2 Design

A 2 (the participant type: pregnant vs. non-pregnant) by 2 (the CCT version: cold vs. hot) mixed experimental design was employed, with the former being varied between groups and the latter being varied within groups. The dependent variable was the average number of cards clicked in 24 rounds of each subtask. The pregnant participants were divided into three subcategories: the first, the second, and the third trimesters of pregnancy. In terms of cross-sectional study, this between-subject design can help us to understand whether there are decision-making changes in different pregnancies to a certain extent; that is, the possible differences of decision-making among the three groups can reflect the changing and developing tendency of risk decision-making during pregnancy to a certain extent. In fact, due to the existing conditions (e.g., it is impossible to eliminate the "learning effect" inevitably generated by repeated test decision-making tasks), we cannot track the behavioral decision-making tendency of each pregnant participant in three pregnancies; therefore, using this cross-sectional study design is conducive to us to understand as much as possible the impact of pregnancy on women's risk decision-making.

2.3 Materials

2.3.1 Measuring Instruments

The revised Chinese version of the Barratt Impulsivity Scale (BIS-11) (Zhou, Xiao, He, Li & Liu, 2006)[2] and the revised Chinese version (Zhang, Diao & Schick, 2004)[3] of the Positive Affect and Negative Affect Scale (PANAS) (Watson, Clark & Tellege, 1988) were used to measure impulsivity and emotional state, respectively. In the current study, the Cronbach's coefficient of the former and the latter was respectively .758 and .864; and in the latter, the Cronbach's coefficient of PA and NA were .881 and .895.

Sensation Seeking was measured by the Chinese revised version (Wang et al., 2000) of the Sensation Seeking Scale-V (SSS-V) compiled by Zuckerman, Eysenck & Eysenck (1978).[4] The SSS-V contains the following four subscales: (a) Thrill and Adventure Seeking (TAS), which refers to the desire to engage in intense and dangerous activities (most activities are recognized or accepted by the society); (b) Experience Seeking (ES), represents seeking all kinds of new and different experiences through thinking and feeling alone; (c) Disinhibition (DIS), represents the enthusiasm for activities that make people excited without any restrictions; (d) Boredom Susceptibility (BS), represents the aversion to mediocre and tedious people or things, and the aversion to stagnation (Xu, Fang & Rao, 2013). The Cronbach's coefficient of SSS-V in this study was .788.

2.3.2 Risk Decision-making Task

The Columbia Card Task (CCT) was used to investigate participants' risk decision-making, utilizing two subtasks: cold CCT and hot CCT. The task includes the following three factors: (a) probability of a loss (1 or 3 loss cards

[2]The scale contains 26 items and is scored by four points (1 = almost none / never, 2 = occasionally, 3 = often, 4 = almost always / all the time), with a total possible score of 26–104. A higher score indicates a higher level of impulsivity.

[3]It contains 9 items (adjectives) for the Positive Affect scale (PA) and 10 items for the Negative Affect scale (NA). Participants were asked to rate, on a 5-point scale ranging from 1 (very slightly or not all) to 5 (extremely), the extent to which they have experienced each emotional state over the past week. The score of individuals' items was added together, with possible total scores for PA and NA ranging from 9 to 45 and 10 to 50, respectively (wherein higher scores indicate higher levels of particular emotional states).

[4]Each subscale contains 10 items, a total of 40 items; 1 point for each item selected corresponding to sensation seeking, with a total possible score of 0–40. A higher score indicates a higher level of sensation seeking.

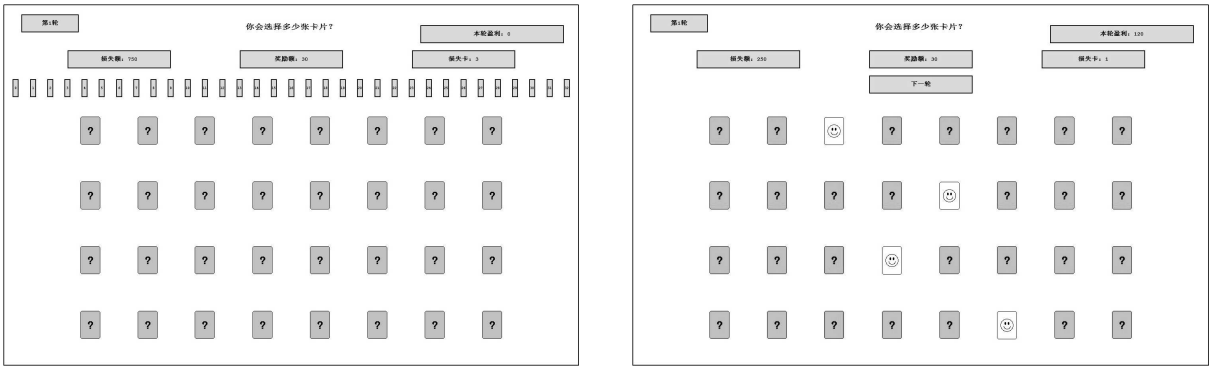


FIGURE 1: Screenshots of the cold CCT (left panel) and the hot CCT (right panel).

out of 32 cards); (b) gain amount (10 or 30 points per gain card); (c) loss amount (250 or 750 points per loss card). Presenting 8 random combinations at all levels of each factor 3 times respectively, resulted in an experimental session of 24 rounds (random presentation). The three factors are always available to participants and that systematically changed across rounds. The experimental program using for human-computer interaction was developed with the E-prime 2.0 Software. The top of the screen displayed the following information for a given round: the number of hidden loss cards, the gain amount of each gain card, and the loss amount of each loss card; and the participants were presented with 32 cards (four rows of 8 cards each) which were shown face down by computer and clicked to display their front faces. The amount of gain or loss represented by each card turned over would be counted to the total payoff of each round.

In the cold CCT, decisions were not made stepwise and there was no immediate feedback, in order to avoid triggering affective processing. A string of 33 small buttons labeled 0-32 were displayed at the top of the screen (see Figure 1, left panel), and the participants were asked to click 1 of these 33 buttons according to the above three factors to indicate how many cards they wanted to turn over on a given round.[5] The participants made only a single, final decision, and could receive feedback (the total payoff of each round) only after the end of each round, which were the guarantee to trigger deliberative processing.

In the hot version, to trigger affective processing, participants were allowed to make stepwise incremental decisions in each round, that is, they clicked cards one by one; and they were provided with immediate feedback in the upper right corner of the screen (revealing the current payoff after adding gain amount or subtracting loss amount) when they clicked on a card turned it over (revealing whether it was a gain or a loss card) (see Figure 1, right panel).[6] In the CCT, because both the possibilities of gain and loss increases with each card that is turned over, turning more cards over is related to greater outcome variability, so this is a riskier strategy than turning fewer cards over; that is, turning more cards over means greater potential returns and greater risks. Therefore, the number of clicked cards can be used to measure the level of risk preference among participants. The higher the average number, the higher the level of risk preference will be; conversely, fewer clicked cards indicate a lower level of risk preference.

2.4 Procedure

The present study was conducted in quiet and bright rooms. After participants signed the informed consent form, they filled in the personal information form and the PANAS. In addition, pregnant participants voluntarily provided the experimenter with their hCG and progesterone data examined at the first trimester of pregnancy in the public hospital.[7] Next, participants completed the CCT. The order of presentation of the two subtasks was ABBA balanced among the participants, each subtask had 24 rounds, and the 24 rounds of each subtask were randomly presented among all participants. After this, participants completed the BIS-11 and the SSS-V, and the order of completion was also ABBA balanced among the participants. After the experiment, the results of 3 of 48 trials were randomly selected, with these scores used as a reward amount after multiplying by .01, with a final reward for each participant of RMB 5-10 Yuan.

[5]When all the selected number of cards were turned over at random or a loss card was encountered, the round ended.

[6]When the gain card was turned over, the amount represented by the gain card would added to the total payoff, the participants could choose to continue to click the cards or stop the round to enter the next round; when the loss card was turned over, the amount represented by the loss card would subtracted from the total payoff and the round. automatically ended.

[7]According to local policy, pregnant women must test hCG and progesterone levels in the public hospital at the first trimester of pregnancy. Only after passing the B-ultrasound examination, they can be allowed to set up health records in the public hospital. And then in this hospital, they can have access to the regular prenatal inspection (paid by themselves), and have access to the delivery services (paid by the medical insurance). As a result, each of them has the hCG and progesterone test reports at the first trimester of pregnancy issued by the public hospital.

TABLE 2: Descriptive statistical results of the two CCT performances of pregnant and non-pregnant women (*N*=240).

Task Type	Pregnant Group (*M*±*SD*, *n*=120)	Non-pregnant Group (*M*±*SD*, *n*=120)
Cold CCT	8.83±3.48	10.85±4.41
Hot CCT	7.95±3.26	9.15±4.50

3 Results

3.1 Comparison of the CCT Performances in Different Groups

3.1.1 Comparison of the CCT performances between pregnant and non-pregnant women

The descriptive statistical results of the two CCT performances of the two groups are shown in Table 2. Taking the participant type and the CCT version as the independent variables and the number of cards clicked as the dependent variable, a two-factor repeated measurement and analysis of variance (ANOVA) was performed (Figure 2). Participant type (pregnant vs. control) had a significant main effect ($F(1, 238) = 17.49$, $p < .0001$, $\eta_p^2 = .068$), indicating the pregnant participants ($M = 8.39\pm3.40$) chose fewer cards than their non-pregnant peers ($M = 10.00\pm4.53$). In addition, the main effect of the CCT version was significant ($F(1, 238) = 14.95$, $p < .0001$, $\eta_p^2 = .059$), indicating that participants chose fewer cards in hot CCT ($M = 8.55\pm3.97$) than in cold CCT ($M = 9.84\pm4.09$), whereas the interaction between the participant type and the CCT version was very small and not significant ($F(1, 238) = 1.51$, $p = .220 > .05$).

3.1.2 Comparison of the CCT performances of participants at different gestational ages

The descriptive statistical results of the two CCT performances of participants at different gestational ages are shown in Table 3. To investigate the difference of risk decision-making as a function of gestational age, the gestational age and CCT version were treated as independent variables, and the number of cards clicked remained the dependent variable, allowing for a two-factor repeated measurement ANOVA to be performed. Risk decision-making tendency differed as a function of gestational age ($F(2, 117) = 12.82$, $p < .0001$, $\eta_p^2 = .180$). Women in the pregnant group also made more conservative decisions in the hot CCT than in the cold CCT ($F(1, 117) = 4.39$, $p = .038 < .05$, $\eta_p^2 = .036$). The interaction between the two variables was very small and not significant ($F(2, 117) = .09$, $p = .916 > .05$). The results of Post hoc multiple comparisons (Figure 3) showed that, in both the cold CCT and the hot CCT, the number of cards clicked was, from least to most: the third trimester < the first trimester < the second trimester, with significant differences between the first and the second trimesters of pregnancy ($p_{\text{cold CCT}} = .043 < .05$; $p_{\text{hot CCT}} = .015 < .05$) and between the second and the third trimesters of pregnancy ($p_{\text{cold CCT}} = .014 < .05$; $p_{\text{hot CCT}} = .001 < .01$). In sum, compared with women in the second trimester of pregnancy, women in the first and the third trimesters of pregnancy have higher risk aversion tendencies in both CCTs.

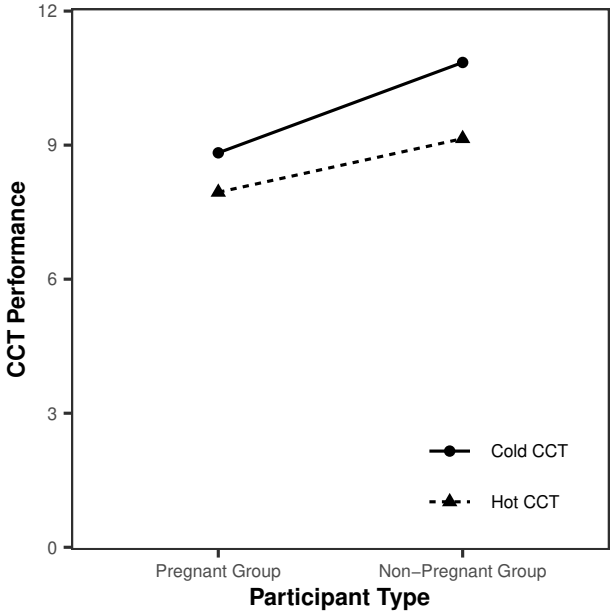


FIGURE 2: Comparison of two CCT performances between pregnant and non-pregnant women (*N*=240).

3.2 Comparison of the Emotional State and Personality Traits in Different Groups

3.2.1 Comparison of the emotional state and personality traits between the pregnant and non-pregnant groups

An independent-sample t-test was used to test the differences in emotional state between the two groups. There was no significant difference in positive emotion scores between the pregnant group ($M = 20.58\pm7.24$) and the non-pregnant group ($M = 20.88\pm6.92$); $t(238) = -.33$, for the difference, $p = .743 > .05$, and no significant difference in negative emotion scores between the pregnant group ($M = 16.02\pm6.14$) and the non-pregnant group ($M = 17.10\pm7.08$); $t(238) = -1.27$, for the difference, $p = .207 > .05$.

An independent-sample t-test was used to test the differences in personality traits between the two groups, the results were as follows: there was no significant difference ($t(238) = -1.42$, $p = .158 > .05$) in impulsivity scores between the pregnant group ($M = 58.22\pm7.51$) and the non-pregnant

TABLE 3: Descriptive statistical results of the two CCT performances of pregnant women at different gestational ages (n=120).

Task Type	the First Trimester (M±SD, n=40)	the Second Trimester (M±SD, n=42)	the Third Trimester (M±SD, n=38)
Cold CCT	8.29±2.78	10.14±4.01	7.95±3.17
Hot CCT	7.47±2.91	9.42±3.41	6.82±2.91

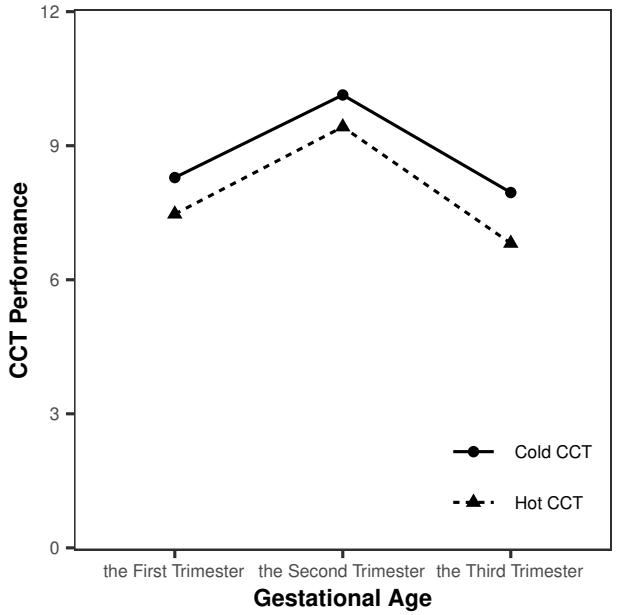


FIGURE 3: Comparison of two CCT performances of pregnant women at different gestational ages (n=240).

group (M = 59.59±7.52), but there was a significant difference (t(238) = –7.10, p < .0001, d = .917) in sensation seeking scores between the pregnant group (M = 11.89±4.99) and the non-pregnant group (M = 16.60±5.27). Further, an independent-sample t-test was used to test the differences in each dimension of sensation seeking between the two groups, the results were as follows: (a) There was a significant difference (t(238) = –5.75, p < .0001, d = .741) in TAS scores between the pregnant group (M = 4.70±2.11) and the non-pregnant group (M = 6.34±2.31); (b) There was a significant difference (t(238) = –4.95, p < .0001, d = .642) in ES scores between the pregnant group (M = 2.19±1.51) and the non-pregnant group (M = 3.26±1.81); (c) There was a significant difference (t(238) = –5.47, p < .0001, d = .705) in DIS scores between the pregnant group (M = 2.72±1.55) and the non-pregnant group (M = 3.92±1.84); (d) There was a significant difference (t(238) = –4.17, p < .0001, d = .538) in BS scores between the pregnant group (M = 2.28±1.54) and the non-pregnant group (M = 3.09±1.47). These results suggest that the pregnant group have lower levels of each dimension of sensation seeking than do the non-pregnant group.

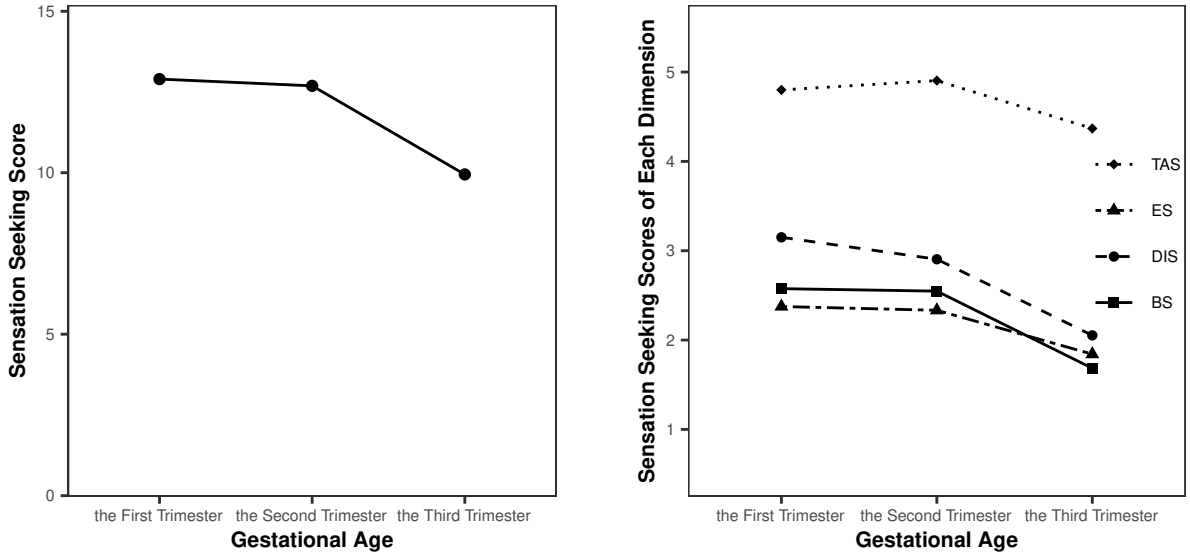
3.2.2 Comparison of the emotional state and personality traits at different gestational ages

The descriptive statistical results of the emotional state and personality traits of participants at different gestational ages are shown in Table 4. A one-way analysis of variance was used to test the differences in emotional state and personality traits at different gestational ages, and the results showed that there was no significant difference in positive and negative emotion scores at different gestational ages ($F_{\text{positive emotion}}$ (2, 117) = .48, p = .622 > .05; $F_{\text{negative emotion}}$ (2, 117) = 2.57, p = .081 > .05); there was no significant difference in impulsivity scores at different gestational ages (F(2, 117) = .34, p = .716 > .05), but there was a significant difference in sensation seeking scores at different gestational ages (F(2, 117) = 4.48, p = .013 < .05, η_p^2 = .071). The results of Post hoc multiple comparisons (Figure 4a) showed that, the sensation seeking scores was, from least to most: the third trimester of pregnancy < the first trimester of pregnancy < the second trimester of pregnancy, with significant differences between the first and the third trimesters of pregnancy (p = .025 < .05;) and between the second and the third trimesters of pregnancy (p = .039 < .05). In sum, compared with women in the third trimester of pregnancy, women in the first and the second trimesters of pregnancy have higher sensation seeking levels.

Further, an independent-sample t-test was used to test the differences in each dimension of sensation seeking at different gestational ages, the results were as follows: there was no significant difference (F_{TAS} (2, 117) = .71, p = .494 > .05; F_{BS} (2, 117) = 1.50, p = .227 > .05) in TAS and ES scores at different gestational ages, but there was a significant difference (F_{DIS} (2, 117) = 5.78, p = .004 < .01, η_p^2 = .090; F_{BS} (2, 117) = 4.49, p = .013 < .05, η_p^2 = .071) in DIS and BS scores at different gestational ages. The results of Post hoc multiple comparisons (Figure 4b) showed that, the DIS and BS scores was, from least to most: the third trimester of pregnancy < the first trimester of pregnancy < the second trimester of pregnancy, with significant differences between the first and the third trimesters of pregnancy (p_{DIS} = .005 < .01; p_{BS} = .029 < .05) and between the second and the third trimesters of pregnancy (p_{DIS} = .036 < .05; p_{BS} = .033 < .05). In sum, compared with women in the third trimester of

TABLE 4: Descriptive statistical results of emotional state and personality traits of pregnant women at different gestational ages (n=120).

Variable	the First Trimester (M±SD, n=40)	the Second Trimester (M±SD, n=42)	the Third Trimester (M±SD, n=38)
Positive Emotion	19.70±6.67	20.79±7.76	21.26±7.33
Negative Emotion	17.40±7.18	16.24±6.60	14.32±3.66
Impulsivity	58.25±8.41	58.86±7.35	57.47±6.77
Sensation Seeking	12.90±4.01	12.69±5.78	9.95±4.45
TAS	4.80±1.94	4.90±2.34	4.37±2.03
ES	2.38±1.58	2.33±1.63	1.84±1.26
DIS	3.15±1.41	2.90±1.62	2.05±1.43
BS	2.58±1.34	2.55±1.63	1.68±1.49



(a) (b)

FIGURE 4: (a) Comparison of sensation seeking scores of pregnant women at different gestational ages. (b) Comparison of sensation seeking scores of each dimension of pregnant women at different gestational ages.

pregnancy, women in the first and the second trimesters of pregnancy have higher DIS and BS levels.

3.3 Analysis of The Relationship between Variables and CCT performance

3.3.1 Correlation analysis of emotional state, personality traits and CCT performances between pregnant and non-pregnant groups

A Pearson correlation analysis was conducted based on the scores of participants' emotional state and personality traits and their two CCT scores of the two groups. The results (in Table 5) revealed that the positive emotion of pregnant women was significantly negatively correlated with their hot CCT scores, while negative emotion and TAS score were significantly positively correlated with their hot CCT scores (ps < .05); the negative emotion and DIS score of non-pregnant women were significantly positively correlated with their hot CCT scores (ps < .05).

3.3.2 Correlation analysis of emotional state, personality traits and CCT performances at different gestational ages

A Pearson correlation analysis was conducted based on the scores of emotional state and personality traits and two CCT scores at different gestational ages. The results revealed that:

TABLE 5: Pearson correlation analysis results of emotional state and personality traits and two CCT performances of two groups.

		Pregnant Group				Non-pregnant Group			
		Cold CCT		Hot CCT		Cold CCT		Hot CCT	
Variable		*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Positive Emotion		.020	.825	−.430***	<.0001	.038	.678	.048	.603
Negative Emotion		.007	.944	.236**	.009	.054	.560	.305**	.001
Impulsivity		−.119	.196	.023	.803	.060	.515	.132	.150
Sensation Seeking	TAS	.072	.434	.233*	.011	−.017	.851	.004	.969
	ES	.057	.536	.049	.595	.111	.226	.049	.597
	DIS	.024	.797	.060	.518	.043	.643	.205*	.025
	BS	−.021	.817	.054	.556	.028	.762	−.034	.711

Note: $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .0001$.

(a) The positive emotion of participants in the first trimester of pregnancy was significantly negatively correlated with their hot CCT scores ($r = –.572$, $p < .0001$), while the remaining variables were not significantly correlated with the two CCT scores ($ps > .05$). (b) For the participants in the second trimester of pregnancy, there was no significant correlation between each variable and the two CCT scores ($ps > .05$). (c) The positive emotion of participants in the third trimester of pregnancy was significantly negatively correlated with their hot CCT scores ($r = –.614$, $p < .0001$), while the remaining variables were not significantly correlated with the two CCT scores ($ps > .05$).

3.3.3 The analysis of the effect of variables on the hot CCT performance

Since participant type (pregnant or not) was correlated with DIS score and hot CCT score, we asked whether the correlation between participant type and hot CCT could be mediated by DIS, using the Process plug-in in SPSS (Hayes, 2013). Choosing Model 4 with a sample size of 5000, the mediating effect of DIS between the pregnant or not and hot CCT performance was significant, with an indirect effect of .414 (95% CI [.019, .864], excluding 0), and a direct effect of .786 (95% CI [–.265, 1.838], including 0). This result indicates that DIS could play a fully mediating role in the effect of the pregnant or not on hot CCT performance (Figure 5).

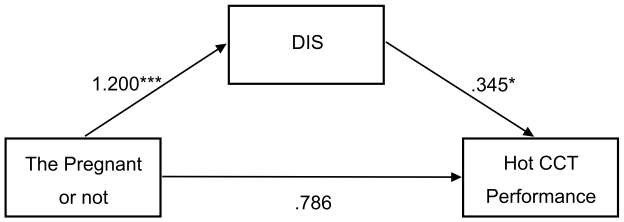


FIGURE 5: The mediating role of the DIS in the relationship between the pregnant or not and hot CCT performance. $^{*}p < .05$, $^{***}p < .0001$.

3.4 Analysis of The Relationship between the Variables and CCT performance of Pregnant Group

3.4.1 Correlation analysis between the Variables and CCT performance of pregnant group

The hot CCT score of pregnant women was also correlated negatively with their hCG levels ($r = –.305$, $p = .001 < .01$) and their progesterone levels ($r = –.411$, $p < .0001$).

3.4.2 Analysis of the effect of progesterone on hot CCT performance in pregnant group

Since progesterone level was correlated with positive emotion ($r = .227$, $p = .013 < .05$), negative emotion ($r = –.260$, $p = .004 < .01$), and hot CCT score, we asked whether the effect of progesterone on hot CCT performance could be mediated by positive and negative emotions, again using the Process plug-in in SPSS (Hayes, 2013), with Model 4 with a sample size of 5000. The mediation test results were as follows:

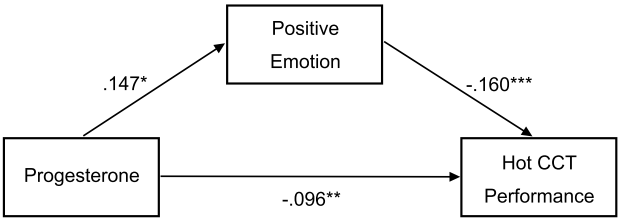


FIGURE 6: The mediating role of positive emotion in the relationship between progesterone and hot CCT performance. $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .0001$.

(a) The mediating effect of positive emotion between progesterone and hot CCT performance was significant, with an indirect effect of –.024 (95% CI [–.047, –.004], excluding 0), and a direct effect of –.096 (95% CI [–.142, .050], excluding 0). This result indicates that positive emotion could play a partial mediating role in the effect of progesterone on hot CCT performance in the pregnant group (Figure 6); (b) The mediating effect of negative emotion between progesterone and hot CCT performance was not significant; the indirect effect was only –.011 (95% CI [–.028, .001], including 0).

4 Discussion

Pregnancy is a major life event in women's life, which leads to great changes in women's psychology and physiology. Psychologically, pregnancy changes women's social roles and their level of sensation seeking. Physiologically, pregnancy causes hormonal changes that vary with gestational age. In this study, the Columbia Card Task, a risk decision-making paradigm based on dual-process theories, was used to explore the impact of the above changes on risk decision-making involving the deliberative processes system versus the affective processes system. The results partly supported our hypothesis: pregnancy seemed to affect women's risk decision-making, making them more cautious and calm and more inclined to avoid risks; moreover, gestational age also affected women's risk decision-making, with women in the first and the third trimesters of pregnancy having a higher risk aversion tendency than women in the second trimester.

Further, from psychological and physiological perspectives, two mediating models were used to attempt to explain the mechanism of the impact of pregnancy on women's risk decision-making. On the one hand, pregnancy reduced women's DIS levels of sensation seeking, thus making them more inclined to risk aversion in the hot CCT involving the affective processes system; moreover, women in the third trimester of pregnancy had lower DIS levels of sensation seeking than did women in the second trimester of pregnancy, and the former showed a higher risk aversion tendency than the latter. On the other hand, pregnancy led to the increase of progesterone level, which increased the positive emotions experienced by pregnant women, which could have made them more prone to risk aversion in the hot CCT involving the affective processes system. The results of this study suggested that sensation seeking, physiological hormones, and emotional state all played some roles in the impacts of pregnancy on women's risk decision-making; although impulsivity was closely related to the deliberative processes system (Hu et al., 2017), pregnancy could not affect risk decision-making involving the deliberative processes system by affecting impulsivity. This seems to mean that there are other cognitive factors that play important roles in the impact of pregnancy on risk decision-making involving the deliberative processes system, which need to be further explored by follow-up studies.

4.1 The Impact of Pregnancy on Risk Decision-making

This study found that pregnant women showed a higher risk aversion tendency than non-pregnant women in both cold CCT and hot CCT. In general, this may be due to the great transformation of women's identity. They need to adapt to the new demands presented by their offspring, and at the same time to face the risk of energy loss and a failure of gene investment (Kinsley & Lambert, 2006). Therefore, they have to adjust their cognitive and emotional state to avoid risks as much as possible. With these changes, they gradually changed from the self-orientation focusing on their own needs and survival to the orientation focusing on the survival and development of their offspring (Numan & Insel, 2003). These changes in pregnant women support the Life History Theory from the side, which posits that in the process of allocating time, resources, and energy to maintain the survival, individuals must make a trade-off between somatic effort (investment in physiological development and material resources) and reproductive effort (investment in competition, courtship, reproduction and parenting) when adapting to a specific environment (Griskevicius, Tybur, Delton & Robertson, 2011). For pregnant women, given that they are in the critical period of their reproductive efforts, many will pay more attention to the quality of their offspring, and to offspring care.

According to the dual-process theories, risk decision-making involves the processing of both the deliberative and affective processes systems. From the analysis of existing studies, it can be known that after a woman becomes pregnant, the two systems will undergo changes to some extent. In terms of the deliberative processes system, pregnancy made women more mentally agile (Christensen, Leach & Mackinnon, 2010; Kinsley et al., 2006), and even improved women's cognitive ability to identify the threat stimuli related to survival, so as to facilitate the survival of their off-

spring (Anderson & Rutherford, 2011). Therefore, in the cold CCT involving the deliberative processes system, pregnant women may pay more attention to the varying levels of the probability, gains, and losses magnitude than non-pregnant women, so that pregnant women are able to choose to avoid risks and gain greater profits. As for the affective processes system, pregnancy may affect the sensation seeking tendency, which is relative to the affective processes system. Therefore, in the hot CCT involving the affective processes system, the feedback would be received after making each choice, with secure profit options better satisfying these pregnant women, and with the risk of loss having a greater impact on them. In conclusion, the impact of pregnancy on women's risk decision-making involves both the deliberative processes system and the affective processes system. Its underlying mechanism will be further analyzed later by discussing the mediation effect test results of this study.

This study also found a gestational age effect, that is, compared with women in the second trimester of pregnancy, women in the first and the third trimesters of pregnancy showed a higher risk aversion tendency in the two CCTs. This is most probably because of psychological differences among pregnant women at different gestational ages (the second trimester vs. the first / the third trimesters) (Wu, 2011; Zhang, 2008). Previous studies have found that the social support of women in the first trimester of pregnancy is significantly higher than that of women in the second and the third trimesters of pregnancy, and this is related to the significant increase in family care and the joy of becoming a new mother that occurs at the beginning of pregnancy (Li et al., 2011). However, at the same time, the first trimester of pregnancy is the most vulnerable stage for pregnant women (Navarrete, Fessler & Eng, 2007), and with the highest prevalence rates of anxiety, depression, other pregnancy-associated discomforts, and miscarriages (Fan et al., 2009).

The present study also found that women in the third trimester of pregnancy had lower levels of sensation seeking than women in the first and the second trimesters of pregnancy, as reflected in the DIS and BS levels. These are probably because women in the third trimester of pregnancy enter a period of extraordinary vulnerability in terms of their psychological and physical states, with the fetus becoming increasingly precious, leading them to worry about various risks that have the potential to harm the fetus, so that they will avoid participating in some social activities, have more tolerance for repeated experience, and are generally cautious. In short, in the first and the third trimesters of pregnancy, women face greater risks and challenges, so more efforts are needed to avoid risks. While in the second trimester of pregnancy, emotional fluctuations are less pronounced, as during this stage their physical condition is relatively good, and they have become more used to their pregnancy, forming a more stable role as a pregnant woman. These existing results and explanations can explain why women in the first and the third trimesters of pregnancy exhibit a greater tendency towards risk aversion than do those in the second trimester of pregnancy in this study. Of course, this result is not completely consistent with the changing trends of different dimensions of sensation seeking in the different gestational ages in this study; however, the two findings confirmed each other, that is, sensation seeking may affect the risk decision-making of women at different gestational ages, but it is not the only factor. This once again demonstrates that, sensation seeking plays an important role in the change of pregnant women's risk decision-making, but beyond that, pregnancy can also affect women's risk decision-making through some cognitive factors, which is an important point that needs to be further addressed for subsequent studies.

4.2 The Role of Sensation Seeking in the Impact of Pregnancy on Risk Decision-making

In this study, it was found that the levels of all dimensions of sensation seeking in pregnant women were lower than those in non-pregnant women; and the first mediator model involving psychological changes showed that DIS of sensation seeking could play a fully mediating role in the impact of pregnancy on hot CCT performance; that is, pregnancy caused the DIS level of women to decrease, thus making them more prone to risk aversion in risk decision-making involving the role of the affective processes system. As mentioned in previous study, pregnancy makes women's social roles undergo changes, as mothers, they will think about their future lives and events in detail, in what some have termed as a "maternal mind" that is conducive to the continuation of future generations and to genetic inheritance (Li et al., 2015). Sensation seeking, this personality characteristic is the need for diverse, novel, complex and intense feelings and experiences, and the willingness to take physical, social, legal or financial risks for these feelings and experiences (Zuckerman, 1994). Therefore, the reduction of sensation seeking level may be the embodiment of one aspect of "maternal mind"; specifically, in order to ensure the safety of the fetus, pregnant women no longer pursue physiological risk-taking activities, novel feelings or experiences, such as stimulating sports, unsafe sexual behaviors, recreational smoking and drinking, drug use, etc., to avoid risks of these activities to the fetus as much as possible. The above findings are also consistent with the existing research results in related fields; namely, individuals with low sensation seeking levels are more sensitive to risks and are less likely to make risky decisions (Arria et al., 2008; Stephenson & Southwell, 2006); pregnant women often maintain a balanced diet and regular exercise, use fewer cosmetic, avoid alcohol and cigarette use, and make other behavioral changes for the sake of health of their offspring (Sevin & Ladwein, 2008). As mentioned in the introduction, sensation seeking is closely related to the

affective processes system of the dual-process theories (Hu et al., 2017), which originates from the sensitivity of the affective processes system to affective cues. Among all dimensions of sensation seeking, DIS is described as seeking for thrills through parties, social drinking, gambling, and other activities to satisfy the desire for the release of inhibition (Zuckerman, 1994), which is a pursuit of emotional and spiritual satisfaction; high sensation seekers think that they have poor performance on emotional management, they have difficulty controlling themselves and easy to act on impulse (Joireman, Anderson & Strathman, 2003), also have strong tendencies to hypomania; primary sociopaths, delinquents and polydrug users scored high on sensation seeking, especially on the DIS (Daitzman & Zuckerman, 1980). Then, in all dimensions, DIS may have the greatest correlation with the affective processes system; therefore, the decrease of the DIS level fully indicates that pregnancy can lead women to avoid some activities that make people feel excited and free from any restrictions and constraints, such as assembly, drinking, sex, and other social activities (Wang et al., 2000).

4.3 The Role of hCG and progesterone in the Impact of Pregnancy on Risk Decision-making

In the present study, the second mediator model, which involved the physiological changes of pregnant women showed that progesterone levels increased, this led the increase of their experience of positive emotions, so that they were more prone to be risk averse in the risk decision-making involving the affective processes system. These results are supported by existing research findings in related fields, revealing that progesterone can condition individuals' emotional states (Bitzer, 2010), and has desirable mood stabilizing, anxiolytic, antidepressant, and sedative effects (Cagnacci et al., 2004; Siddle et al., 1991); so with the increase of progesterone, women's emotions may be more stable and positive emotions may increase. A previous study has shown that positive emotion can promote cognitive flexibility, leading to a higher-level thinking and a more future-oriented perspective (Pyone & Isen, 2011). Another study found that some individuals would choose to be risk averse when they experienced positive emotions in order to maintain a good emotional experience (e.g., Bi, 2006; Chuang & Lin, 2007), and pregnant women may be just such individuals. After all, pregnancy is a major life event, and the future orientation during pregnancy causes women to have positive expectations (Yamamoto, 1996), which in turn leads to risk aversion.

The present study also found that hCG level correlated with hot CCT scores in pregnant women, possibly because the main role of hCG in pregnancy is to promote the secretion of progesterone (Wang, Zhang, Gao & Cheng, 1987), but it has nothing to do with emotional changes. In other words, hCG did not affect risk decision-making by affecting emotions, but indirectly by promoting the secretion of progesterone. More importantly, the above findings of the present study proposed the further consummation direction from the angle of methodology to existing research of regarding the impact of pregnancy on intertemporal choice. Recently, in an effort to further verify the influence of psychological factors related to pregnancy on future orientation and intertemporal choice preferences of women, some Chinese scholars have assessed the pregnancy-associated psychological state of women of reproductive age under laboratory conditions primed by video induction method, in an effort to eliminate the interference associated with physiological factors such as hormone levels (Li et al., 2015, 2018). While this allows for better experimental control, pregnancy is inevitably associated with substantial physiological and psychological changes, and it is the combination of physiological, psychological, and environmental factors that induces the decision-making and behavior changes observed in new mothers. The effect of hormones on individuals does not change based on an individual's will. Therefore, we believe that the ecological validity of a study will be weakened if women who have never had a normal pregnancy are asked to imagine pregnancy in order to investigate the impact of pregnancy on their decision-making behavior; and because of this, in this study, we attempts to find some connections between behavioral decision-making and physiological factors. In light of the present and previous findings, progesterone clearly affects the decision-making behavior of pregnant women, and as such studies should not exclude the measurement of such physiological hormones.

4.4 Innovation, Limitation and Prospect

The current research extends the research field of risk decision-making, its innovations lie in: (a) In terms of participants, this study focused on pregnant women as a special group. We concluded that changes in emotional state, sensation seeking, and progesterone occurring accompany pregnancy and can lead to changes in women's risk decision-making tendencies. The effective application of the results of this study might help pregnant women improve their ability to accurately assess decision-making with respect to risks. (b) The effects of two physiological hormones, hCG and progesterone on risk decision-making in pregnant women were first investigated in this study, in an attempt to explain the impact of pregnancy on women's risk decision-making from psychological and physiological aspects at the same time. We explored the internal mechanism in a preliminary way, providing a foundation for future research. (c) We adopted the CCT, which was the effective experimental paradigms for the study of individual differences in risk decision-making under the framework of the dual-process theories. Based on the dual-process theories of decision-making, we fully in-

vestigated the impact of pregnancy on risk decision-making from two aspects of deliberative processing and affective processing.

The results and limitations of this study suggest future research. First, it would be useful to carry out a longitudinal tracking study on individuals in the whole three stages of pregnancy, as well as the postpartum periods.

Second, because of lack of testing qualification and condition of physiological hormones testing (the data of hCG and progesterone can only be obtained by pregnant women providing voluntarily of their pregnancy check-up report), this study is not comprehensive enough to explore the hormonal effects of pregnancy on risk decision-making. For example, the present study observed an apparent mediating role of DIS of sensation seeking in the impact of pregnancy on risk decision-making. An earlier study found that the DIS level of sensation seeking correlated with sex hormones, the testosterone, estradiol and estrone in men with high DIS scores were higher than those with low scores (Daitzman & Zuckerman, 1980). This result suggests that sex hormones not measured in the present study may also play a role in the impact of pregnancy on risk decision-making. In addition, the mediating model of the influencing mechanism explored here explains only the internal mechanism of the risk decision-making involving the role of the affective processes system (hot CCT), while the issue of how pregnancy affects the risk decision-making involving the role of the deliberative processes system (cold CCT) has not been clearly explained. It can be seen that in the future, more relevant factors (cognitive and physiological factors) should be explored in order to fully reveal the mechanism of pregnancy's effect on women's risk decision-making.

Third, the present study only focused on the changes of economic risk decision-making during pregnancy, but not on the changes of pregnant women's health, safety, and interpersonal risk decision-making. In the future, the research content should be extended to other risk decision-making fields or other decision-making (such as game decision-making or multi-domain intertemporal choice etc.), and should pay attention to the differences among different types of decision-making.

Finally, certain structural changes in the brain during pregnancy in some mammals are well known in research field, but so far, there is little evidences regarding these changes in brain structure during pregnancy in humans. Therefore, future key areas of research include the in-depth exploration of the neurophysiological mechanisms underlying this specific risk aversion tendency in pregnant women.

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