How Attachment Affects Economic Decision-making: Efficiency, Cooperation, and Initiative To Negotiate In A Centipede Context

by

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Abstract

When one feels stressed or anxious in a relationship, they tend to make bad decisions for themselves and their close ones. I import from developmental psychology the adult attachment theory to examine whether different levels of anxious and avoidant attachment have an analogous impact on one's economic decision-making. I examine participants' behaviors and beliefs in a centipede game setting after collecting their attachment scores. I find that anxious attachment predicts lower individual payoffs, lower efficiency of outcome, lower trust level, lower stability of cooperation, and a lower initiative to cooperate, whereas avoidant attachment predicts a lower trust level. I also find that introducing a simple negotiation stage temporarily increases the likelihood of cooperation. The results have valuable indications for parenting styles and management and organizations, and novel contributions to human decision-making process as well as the centipede game literature.

Key Words: *Human Decision Making, Attachment Style, Negotiation, Cooperation*

Preface

This is an individual project conducted by an undergraduate senior who majors in Economics and Data Science and also pursues a concentration in Psychology. Capitalizing my enthusiasm in social and developmental psychology, I have designed and proctored experiments to explore the relationships between insecure attachments and economic decision-making. I wish to draw insights from this rich dataset I have put together to better advise parents, organization managers, as well as the insecurely attached decision makers.

1 Introduction

Our economic-decision making process is affected by a variety of factors, including cognitive ability, personality, and preferences (Gill and Prowse, 2016; Falk et al., 2018). Economic decision-making is always strongly interactive and relationship-based. Examples vary from daily activities like deciding on a dinner place to critical events like political negotiations. As people can exhibit drastically different behaviors when exposed to a social setting compared with an individual setting, it is therefore important to understand what factors are responsible for those differences.

I import adult attachment theory to examine the impact of insecurity in close relationships on decision-making. Providing a useful distinction between "Anxious" and "Avoidant" attachments, adult attachment style empowers me to break down insecurity in close relationships into two dimensions and examine their impacts on decision-making separately. My study seeks answers to the following questions: (i) Do insecure attachments influence agent performance in a repeated increasing-pie centipede game, in terms of invoking less trusting beliefs, impairing efficiency at both the individual and group level, and reducing initiative to negotiate, after including demographics and risk preference as moderators? (ii)Do anxious attachment and avoidant attachment differ in the level of those influences? (iii) Does adding the option to negotiate increase the efficiency at either the individual or group level, or both?

By analyzing 63 independent groups across 17 experiment sessions, I find that anxious attachment is correlated with lower individual payoffs, lower efficiency of outcome, lower trust level, lower stability of cooperation, and a lower initiative to co-operate, and avoidant attachment predicts a lower trust level. Moreover, introducing a costless, pre-programmed negotiation stage, despite possessing cheap-talk characteristics, drastically increases the likelihood of cooperation. Applications of those findings include stronger reasons to emphasize emotional care and accompany in parenting, advice for organization managers to create relationship-wise secure working environments, as well as implications for people with insecure attachments to improve their decision-making by further recognizing their bias.

Formulated in Bowlby (1988), the attachment theory explains infants' anxiety and grief when the caregiver is away as a normal reaction to the stressful situation. From an evolutionary perspective, this is a defensive pattern human learn to better protect themselves (Prior and Glaser, 2006). While the attachment theory initially focused only on infant-caregiver relationships, it was later argued that the attachment styles established in one's infancy play a long-lasting role, which gave birth to the adult attachment theory (Mikulincer and Shaver, 2012). Meta-analyses have shown that one's attachment style across childhood and adulthood stays generally consistent (Fraley, 2002; Pinquart, Feußner and Ahnert, 2013). The level of perceived risk is found to be challenging that stability, as children exposed to higher social risks, i.e. family estrangement, parental depression, or school bullying are more likely to change from secure to insecure attachments (Pinquart, Feußner and Ahnert, 2013). In addition, a priming method has been shown to have a positive effect on one's attachment status (Carnelley and Rowe, 2007).

Different parental responses typically result in different patterns of attachment styles. Supportive, responsive parenting styles nurture secure attachments, whereas abusive, neglectful, or simply absent parents usually raise insecurely attached kids. Though many models have been developed and different terminologies have been coined, a majority of measures follow the pioneer model in Ainsworth et al. (1978), dividing insecure attachment styles into two main subcategories: *Anxiety* and *Avoidance*.

As summarized in Yip et al. (2018), *anxious attachment* is a result of unreliable or abusive caregiving relationships, manifested through one's negative self-perception and preoccupation with others' affirmation. These dispositions are likely to affect one's decision-making from many angles. Previous studies have shown that anxious attachment predicts risk-loving behaviors (Li et al., 2019). Moreover, Fraley et al. (2006) has found that anxious people are more vigilant and sensitive to social and emotional cues, by showing that the anxiously attached react more quickly to people's change in expressions, and have a higher risk of misinterpreting other's mood as well. As the anxiously attached seem to put more care and attention on others to preserve their affection and support, it is reasonable to hypothesize that they will tend to think and worry more than their secure counterparts when engaged in an interactive game.

Avoidant attachment, on the other hand, is shaped by neglectful or punishing caregiving relationships, which typically causes the child to perceive others more negatively and to defensively keep a considerable distance from the significant or close others (Yip et al., 2018). As a result, it accounts for their tendency to deal with stress alone and intensely utilize denials (Mikulincer and Shaver, 2003). These patterns can also hinder one's ability to perform social tasks. For instance, agents with an avoidant attachment with their agent are more likely to make ill-fated deals in negotiations (Lee and Thompson, 2011). In a moral dilemmas setting, avoidant attachment, along with anxious attachment, is correlated with a lower threshold to harm others and consequently lower empathy and reduced desire to help others (Maranges, Chen and Conway, 2022). A similar tendency to cooperate less is found in a prisoner dilemma and a one-shot public goods game too (Gao et al., 2020; Taheri, Rotshtein and Beierholm, 2018).

Exposure to psychological threats activates one's attachment system, generating attachment needs that need to be addressed through social and relational support

(Bowlby, 1982). This typically precedes certain behavioral patterns striving to reclaim a sense of security (Mikulincer and Shaver, 2007). However, those attempts to earn support from others may be fawning, disruptive, and impulsive. Since many of the situations that require interactive economic-making also feature strangeness, insecurity, and cognitive or emotional threat, I believe that there is a natural activation process of one's attachment styles when making those decisions. For example, there is evidence that changes in employment relationships have a strong impact on people's attachment-seeking behavior (Albert et al., 2015).

Centipede game was originally introduced in Rosenthal (1981). It has been widely studied as a solid example of the "failure of backward induction". Figure 1 presents a standard version of the centipede game first crafted for an experimental purpose in McKelvey and Palfrey (1992). Players can choose between *In*(*Take*) and *Out*(*Pass*) alternately, and the group payoff doubles whenever a player chooses "In". The unique subgame-perfect Nash Equilibrium (SPNE) in this game as an outcome of backward induction involves always choosing "Out" at every node. However, there is a substantial amount of evidence showing that people's behaviors rarely align with the predictions of Nash Equilibrium in this game (Rapoport et al., 2003; Zauner, 1999; McKelvey and Palfrey, 1992). Instead of exiting the game at the very first node, most players proceed to a later stage, and it was shown that the deviation from the SPNE becomes more and more drastic as the length of the game increases (Ponti, 2000).

Scholars have been proposing various theories to explain the seemingly irrational outcomes. A candidate explanation argues that the population may simply lack the ability to perform backward induction. The theory was made popular since Palacios-Huerta and Volij (2009) showed that sophisticated chess players played the SPNE at a rate of 69 percent, and Grandmasters ended the game immediately every single time. However, Levitt, List and Sadoff (2011) soon found contradictory results, questioning the claim that normal people lack the ability to backward induct. This claim regarding the limit of one's cognitive ability is summarized by the Theory of Bounded Rationality, which contends that agents in real life do not necessarily maximize their utility. Due to the complexity of the environment and the limit of one's cognitive ability, one may choose a good enough, not necessarily the best option, to simplify the decision-making process (Campitelli and Gobet, 2010). When someone is not playing the SPNE in the centipede game, other players will then have incentives to not play SPNE either, to exploit the "errors" of their opponents. This possibility is captured by the Quantum Response Equilibrium (QRE) model and its later extensive-form variation AQRE, as well as a variation accounting for altruistic players AQRE+ (McKelvey and Palfrey, 1992, 1995, 1998).

Another explanation with growing popularity is the cognitive hierarchy theory (Camerer, Ho and Chong, 2004). As an expansion on bounded rationality, the cognitive hierarchy theory suggests that each player plays a strategy that is the best response according to their belief of others. The theory defines types of players by first assuming a level-0 type with certain characteristics. Then level-1 players are those who best-respond to level-0 players, and inductively, level-k players are best-responders to level-(k-1) players. One then, based on their belief over the distribution of different types of players, conjures a strategy that serves as the best response for them. Kawagoe and Takizawa (2012) shows that in an increasing-pie centipede game the cognitive hierarchy model assuming a Poisson distribution and that level-0 types play randomly has the highest explanatory power, concluding that a majority of players are level-2. However, it is fair to say that the level-k model relies on too many assumptions and still lacks the power to explain the data alone (García-Pola, Iriberri and Kovářík, 2020).

Besides all those promising arguments, I want to emphasize here a classical one that dates back to McKelvey and Palfrey (1992), observing that there is heterogeneity in player types. For example, some players are hypothesized as altruistic, i.e., caring not only about their own payoffs but also their opponents', and including this prior in a model helps explain the data better. Additionally, Smead (2008) adopted an evolutionary approach to predict cooperative behaviors in a repeated round setting. In this sense, a further deviation is connected to an increased level of cooperation and higher efficiency, given that each time the game proceeds to the next node the payoff for the group increases.

As this study mainly explores the heterogeneity in player types and how it relates to attachment styles, I am also interested in how people's beliefs reflect their perception of others and self in terms of trust level and how that influences the efficiency of the game outcome. Considering the fact that there are similarities between a centipede game and a repeated trust game, trust between the players is fundamental for cooperation, leading to substantial deviations from the SPNE. Therefore, I elicit beliefs for the sake of understanding perceptions. Taking simplicity as a priority, I borrow Wang (2022)'s design to directly elicit players' first- and second-order beliefs in the centipede game to make more confident conclusions on elicited beliefs without making too many assumptions.

I choose the increasing-pie centipede game for several reasons. Firstly, I want to mimic an interactive social relationship. The dynamic setting of the centipede game, along with the multi-rounded structure, engages participants with a repetitive and interactive environment. Secondly, the game should involve both cooperation and competition, to allow for analysis of trust level and negotiation. Last but not least, the centipede game requires players to perform higher-order reasoning, which makes it possible for us to access their beliefs.

I include risk preferences as a control variable because it was shown to have a strong correlation with attachment styles according to a recent study (Li et al., 2019). Meanwhile, Crosetto and Mantovani (2018) have recently found that risk preference predicts behaviors in a centipede game. In this study, I find support for the latter but not the former.

This study is innovative because it is the first to adopt a centipede game to measure the influence of attachment styles. Compared with previous studies which mainly examined simultaneous structures, the centipede game has the potential to reveal higher-order beliefs with its sequential nature. This empowers me to examine the levels of trust as well as how they believe the other perceives themselves of different attachments. In addition, I get to disentangle rational trusting behaviors and irrational fawning behaviors. Since the relatively complex game structure also increases the harshness of cognitive threat presented to the players, I contend that it better mimics a real activation process of attachments in real life.

Another innovation of this study is that I examine the extent to which each attachment takes initiative when there is a chance for negotiation. Despite evidence showing that insecure attachment predicts worse negotiation performance in a principal-agent context and more adoption of dominating strategies, there is little, if not none, study exploring the interaction between attachment styles and the initiative to negotiate (Lee and Thompson, 2011; Ben-Ari and Hirshberg, 2009). However, negotiation opportunities should not be taken for granted. It needs someone to start it, and there is an advantage to being the proposer. Those who take the initiative and make the first offer are usually the biggest winners, mainly as a result of the famous "anchoring effect"(Gunia et al., 2013). Therefore, insecurely attached individuals will be in a disadvantaged position if they have reduced initiative to negotiate.

This study utilizes a novel experimental design to examine whether different attachment styles take initiative with distinct frequency. To our best knowledge, little or no studies have provided a fixed option to negotiate in a centipede game, despite strong evidence that adding communication usually increases the likelihood of cooperation. In our study, one of the roles was given an opportunity to send a predetermined message that proposes mutual strategies toward a maximized group payoff. This message is, by definition from Crawford and Sobel (1982), a cheap talk. It would be interesting to see if simply adding this option impacts the player's behaviors and beliefs or not.

This paper is structured as follows: Section II introduces the experimental design. Section III presents the results. Section IV provides a discussion of significance, limitations, theoretical implications, and future research directions, followed by concluding remarks.

2 Experimental Design

I ran 17 offline two-participant sessions with a total of 126 participants in the NYU Shanghai Behavior & Experimental Economics Laboratory (SHBEEL) in November 2022 and March 2023 in China, following two pilot sessions. The entire experiment was delivered in English. Each session contained 4 to 12 participants. 4 is the minimum number for the session to avoid colluding between acquaintances since the subjects were paired randomly. The subject pool was limited to NYU Shanghai community members to ensure that all of the subjects can enter the behavioral lab at NYU Shanghai. Each session lasted approximately 45 minutes and paid a show-up fee of 20 RMB. The average payment was 65.65 RMB (the exchange rate was approximately 7.11 RMB to 1 USD at that time). If the number of participants attending the session was odd, then I asked the one who arrived last to leave and I paid them a 20 RMB show-up fee. Any participants who believed having taken any game theory heavy courses were excluded.

Before attending the online sessions for the experiment, participants were asked to sign up through a sign-up form on Qualtrics. In the 10-minute signing-up process, they were asked to fill out a questionnaire for demographics, and attachment styles measurement, followed by a risk elicitation task. As per the convention in Psychology, I did not pay them for filling out the attachment and demographics questionnaire. In comparison, the risk elicitation task was incentive-compatible. They were then asked to provide their contact information (WeChat ID, email address). At the end of the form, they were instructed to sign up for a timeslot for the following paid experiment.

2.1 Demographics

I collected demographic information to use as control variables, which includes age, gender, born place (urban v.s rural), monthly disposable income, and Chinese (v.s international). It is worth mentioning that I included the last variable based on the fact that our sample size is diverse in terms of cultural backgrounds. NYU Shanghai is unique in the sense that its Chinese students all had to go through the Chinese college entrance exam, namely the Gaokao. One may argue that the education Chinese students have received puts emphasis on different aspects than the one received by a typical international student. Also, Chinese students might, to varying extents, suffer from being non-native English speakers, given that the entire study was in English. Therefore, I deem it appropriate to control for this status.

2.2 Measuring Attachment Styles

I used the 20-item questionnaire, Experiences in Close Relationships Revised General Short Form (ECR-R-GSF), designed and validated in Wilkinson (2011) as the main measure to elicit attachment styles. It is a revision of the more popular questionnaire Experiences in Close Relationships (ECR) (Brennan, Clark and Shaver, 1998). The result measures attachment styles on two dimensions: *Anxiety* and *Avoidance*. A lower score on each indicates a higher level of security. The lower bound and higher bound for each dimension is 10 and 50, respectively[1]. I directly used the scores as independent variables for the regression analysis.

I decided to use ECR-R-GSF for the following two reasons. (i) Compared with ECR, which includes questions like *I worry that romantic partners won't care about me as much as I care about them* that require respondents to have had romantic relationships before, ECR-R-GSF is friendly to the general population who may have no previous romantic experiences. Taking the previous example, the same question is rephrased into *I often worry that other people don't care as much about me as I care about them.* Considering the fact that our subject pool is consist of mainly college students, it will be costly and biased to exclude based on relationship experiences. The external validity of this study will not be damaged, since we do make economic decisions very often with general others, instead of our romantic partners. (ii) This questionnaire has a validated Chinese version in Hao, Chan and Wilkinson (2019), which not only supports its validity in China but also empowers us to expand our subject pool to Chinese in future studies.

2.3 The Bomb Task

While Crosetto and Mantovani (2018) used a self-report to elicit risk preferences, our study adopted an incentive-compatible measure. I chose the static Bomb Risk Elicitation Task (BRET) in Crosetto and Filippin (2013). Subjects were provided

[1]The detailed explanation for the measure and individual scores regarding the attachment style were provided at the end of the session upon request.

100 boxes with 99 empty ones and one containing a bomb. They were given a chance to choose a number $k^* \in [0, 100]$ that corresponds to the number of boxes they want to open. The location of the bomb $b \in [1, 100]$ was determined by a random number generator. The payoff (in RMB) was determined by the function

$$\pi(k^*|b) = \begin{cases} 0.4k^* & k^* \leq b \\ 0 & k^* > b \end{cases} \tag{1}$$

As summarized in Crosetto and Filippin (2013), a risk-neutral subject will choose to open 50 boxes, and a higher choice indicates more risk-loving. The mode of our sample is 50, which indicates that a majority of people elicited neutral risk preferences.

In our design, the subjects would not get instant feedback after they make the choice. Instead, they would only know the result if they choose to participate in the follow-up experiment. This delayed feedback was implemented to avoid any spill-over effect to the centipede game. It also encouraged subjects to come to the later session, reducing the likelihood of a no-show.

I asked the participants to complete both the ECR-R-GSF and the bomb game during the sign-up process. Given the relatively long interval between sign-up and the experiment, the spill-over effect from those measurements to behaviors in the centipede game was minimized. The result of the bomb game was provided at the end of the experiment session, where the participants were asked to initiate a randomizer and find out the location of the bomb. On average, the participant choice was 50.85, the bomb label was 51.17, and the average payment for this task was 8.52 RMB. The distribution is shown in Figure 1

The main advantage to pick BRET is that it is one of the most intuitive designs among incentive-compatible risk elicitation methods, and it can be easily adapted

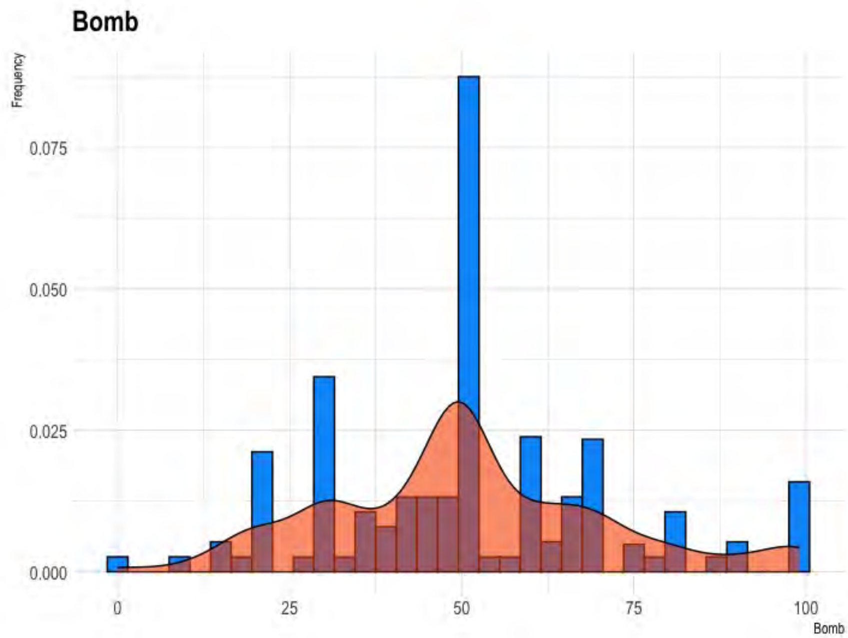

Figure 1: BRET Choice Distribution

into a survey format. Compared with popular multiple price list methods like Holt and Laury (2002), it requires less cognitive effort, which can be more easily incorporated into the already lengthy sign-up form. The dynamic BRET and the Balloon Analogue Risk Task (BART), though may create more immersive experiences for the participants, are not compatible with a simple survey format (Lejuez, Zvolensky and Pedulla, 2003). If I instead include the task in the main experiment session, then we have enough reasons to worry that this task may affect their decision-making in the centipede game, or the other way around, since having the idea of "risk" in mind may prime the participants to perceive the centipede game as more of a gambling task, and the result of the centipede game may cause them to hedge or gamble during the risk task. From a design perspective, it is best to only include the main centipede task in the main section.

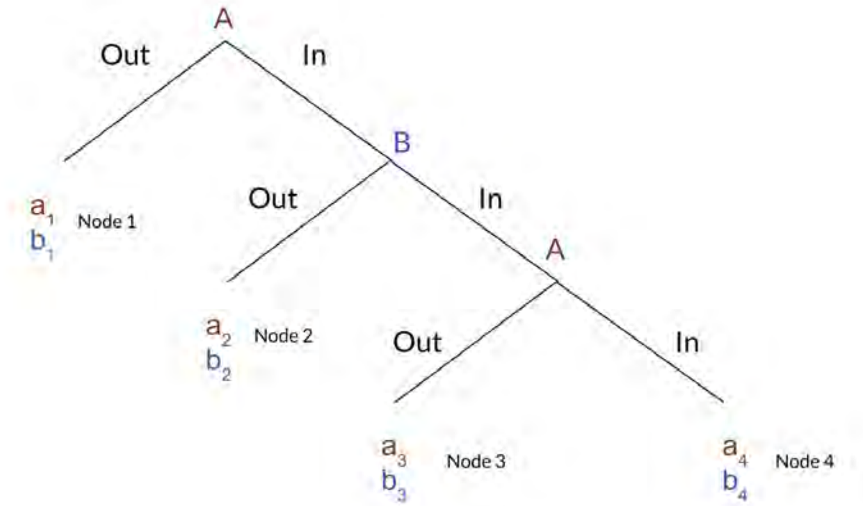

Figure 2: General Centipede Game Structure

2.4 Main Centipede Game

A three-legged two-player increasing-pie multi-rounded centipede game was played in the main experiment sessions. The game structure is displayed in Figure 2. The wording of the choices, i.e. *In* v.s *Out*, follows Wang (2022). To qualify for a centipede game, the game's payoff structure has to satisfy

$$a_1 > a_2, b_2 > b_3, a_3 > a_4, b_3 < b_4$$

To generate comparable results, I chose a payoff structure consistent with the initial design in McKelvey and Palfrey (1992) where the total payoff doubles each time the game proceeds and standardized $(a_1, b_1) = (4,1)$ as shown in Figure 3. I awarded the participants points[2] and then manipulate the exchange rate to reach a proper level of compensation.

The entire game was computer-based. I coded the program using o-tree (Chen,

[2] I phrased it as "coins" to make the setting more realistic and fun, and it goes well with the betting nature of the Bet Stage

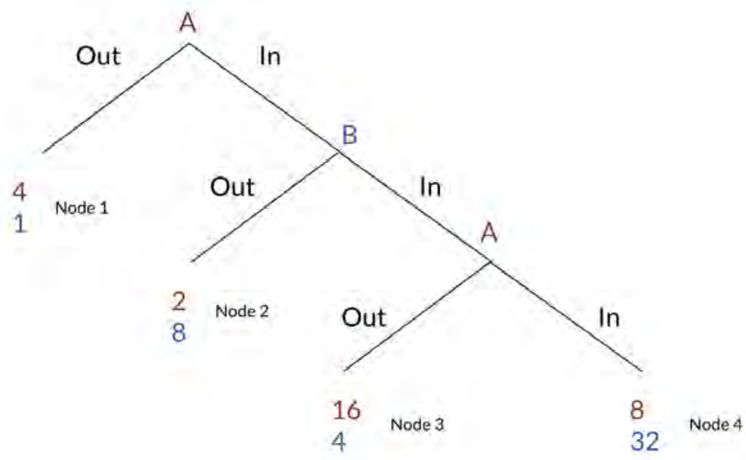

Figure 3: Centipede Game with Payoff

Schonger and Wickens, 2016). The full instructions were shown on the screen once, followed by 2 trial rounds and 12 formal rounds. The participants were given an unlimited amount of time to read the instructions. This is to make sure that they fully understand the game structure before they move on. In comparison, all the pages that ask the participants to make choices included a time limit. I intentionally do this because I want to add time pressure to the participants, thereby increasing their stress level (Lehto, 2013). Combined with the math-intensive task and the lengthy instructions, a stressful environment was manually created to activate the attachment systems of the participants.

Two trial rounds were granted for participants to practice, which had no impact on their payments. This is because, during the pilot sessions, most of the pilots failed to make a choice within the time limit at some stage in the first two rounds, yielding missing data. The two trial rounds therefore helped the participants learn the game by doing, consequently providing less noisy information for us. Besides, participants are allowed to ask for clarifications about the game by sending a private message or raising their hands during the session.

Table 1: Strategies Available

	Player A	Player B
In-In/In	"In" at first and third node	"In" at second node
In-Out	"In" at first and "Out" at third node	X
Out	"Out" at first node	"Out" at second node

Note: Specific descriptions for participants are slightly different with more clarifications. Please refer to Appendix for detailed instructions.

I chose the three-legged variant of the centipede game because it is easier for us to elicit beliefs. Should the game has more legs and more nodes, it became somehow impossible for participants to articulate their higher-order beliefs. It is undoubtedly an outrageous demand for participants to understand questions like "please write down how likely you believe player B believed you believed them believed you played In?". On the other hand, three legs are enough to capture most of the informative behaviors, given that in an increasing-pie game a majority of players are usually only level-1 and level-2 thinkers (Kawagoe and Takizawa, 2012).

Each round starts with the Play Stage, which asks participants to specify what strategies they want to play for this round. The choices come in normal form, as shown in Table **??**. The names of the choices and the corresponding detailed description were displayed on the screen at once to the participants. The choices were then automatically played by the program to determine the outcome of the game. The time limit for the Play Stage is 60 seconds.

A Bet Stage followed the Play Stage. Participants were given 5 free points as chips to place on each betting round, for a total of two rounds. The participants were instructed to use up all of the points for betting. If they failed to use all the points the program would not allow them to continue. The time limit for each betting round is 60 seconds.

The first round of betting aimed to elicit participants' first-order beliefs about their co-player. This gave them a chance to gamble on the choice their co-player made to help us examine the level of trust they have in their co-players. Player As, for example, were asked to freely allocate all 5 chips on the two choices B had for the Play Stage, "In" and "Out", with the same detailed explanations Player Bs got in the Play Stage. Each point could then be interpreted as 20% confidence in the choice by the player, assuming players were profit-maximizing given their beliefs. The bet pays 1 to 1 in the unit of coins.

The second round of betting aimed to elicit participants' second-order beliefs. Participants are asked to guess what their co-players have bet on in the first round of betting. Similar to the first round, they can freely allocate the 5 chips. The specific payoff function[3] for this round is:

$$\pi(B_i^1|B_{-i}^2) = \sum_{k=1} min(b_{ik}^1, b_{-ik}^2) \tag{2}$$

where b_{ik}^j represents the number of coins player i bets on the kth option in betting round j, and B_i^j represents the entire set of options b on which player i can place their bet in round j. Simply speaking, the closer one's bet in round two matched the exact distribution of bets their co-player placed in round one, the higher they would earn.

Starting from the 7th round of the 12 rounds, participants were instructed of a newly-introduced Negotiation Stage. Specifically, Player A would be able to click "Yes" in the Negotiate Stage to send a negotiation message to Player B before the start of each round. The message says *Let's cooperate, I will play "In-In", please play "In"* and remains the same for the remaining rounds. Nothing will happen if they

[3]Unit is in coins.

choose not to negotiate. Player B was only informed of the possibility that player A may send forward a message[4], but knew nothing about the exact content.

I introduced the Negotiation Stage at the 7th round to keep the results of the first six rounds independent from the rounds with this treatment. This allows us to examine the effect of adding the negotiation probability on the game outcome, as well as how different attachment styles react to this option while retaining the results of the original game. Also, I did not want to give them information on possible strategies to play the game before they had clearly understood the game. After they learned through the first 8 rounds (counting in the 2 trial rounds), it's unlikely for them to be surprised that a combination of "In-In" and "In" is the result that yields the highest payoff for the entire group.

At the end of each round, participants received feedback on the following pieces of information: (i) the choice their co-player had made, (ii) the payoff they had earned, and (iii) the ending node of this round with a figure of the game structure. The payoff for each round was the sum of the points earned in the Play Stage and Bet Stage. If one failed to make a choice at any stage in a round, then they would earn 0 in that round[5]. The payoff was calculated in a way to discourage hedging strategy: Out of the 12 rounds, the four rounds with the highest payoffs and the four rounds with the lowest payoffs were dropped. The average payoff of the remaining four rounds was calculated as the final payoff for this game. This way to calculate systematically minimized risk for the participants so that they would be less likely to further avoid risk by hedging. Points were converted to RMB with the exchange rate of 1:2.5 for the centipede game. In the half-hour-long game, the participants received on average

[4] I explicitly told Player A that they may or may not follow the plan proposed in the negotiation message to clarify out of the concern that they may misunderstand the instruction but I did not tell Player B this because I believed this was self-explanatory for B.

[5] To make it fair for the other player, I awarded the co-player 70 RMB in those situations, which exceeded the average payoff.

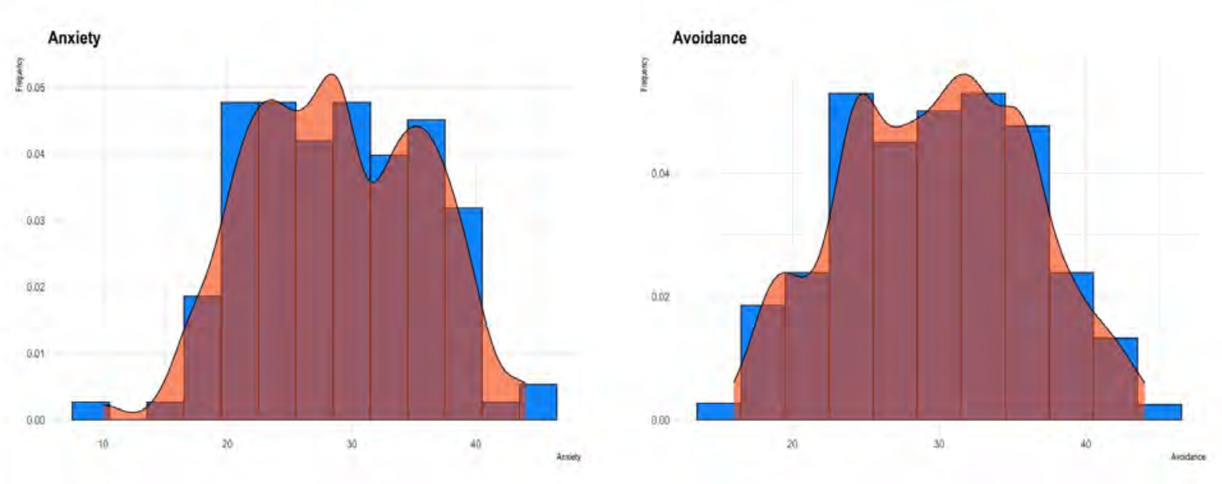

Figure 4: Attachment Scores Distribution

38.91 RMB for this game.

3 Results

3.1 Summary Statistics

Among all 126 participants, the mean score on Avoidance scale is 29.82 and the mean score on Anxiety scale is 28.78. The distributions are shown in Figure 4.[6] Table 2 gives an overview of the choicesindividual payoff, group payoff, negotiate decision, and game outcome of each round. Table 3 gives a detailed view of the beliefs elicited.

3.2 Efficiency

As said in previous sections, there are fundamental conflicts between the SPNE and the welfare-maximizing outcome in a centipede game. Here I examine how public

[6]Our results are comparable to the ones in Wilkinson (2011), the developer of this measure, as well as the ones in a Chinese infant-mother sample (Archer et al., 2015).

Table 2: Choices and Outcomes Overview

Round	Role	Strategy				End Node	Negotiate	Payoff	
		In-In	In-Out	In	Out			Individual	Group
3	A	.32	.40		.27	2.34		31.08	71.08
	B			.48	.52			39.97	
4	A	.29	.38		.33	2.27		30.79	68.78
	B			.60	.40			37.98	
5	A	.30	.40		.30	2.25		31.70	66.98
	B			.56	.44			35.27	
6	A	.25	.46		.29	2.37		32.40	71.22
	B			.57	.43			38.84	
7	A	.25	.46		.29	2.24		32.60	67.57
	B			.49	.51			34.95	
8	A	.30	.40		.30	2.32		32.68	69.92
	B			.56	.44			37.25	
9	A	.65	.25		.10	3.25	.79	37.75	105.41
	B			.83	.17			67.68	
10	A	.54	.27		.19	2.94	.67	37.49	94.21
	B			.78	.22			56.71	
11	A	.48	.38		.14	2.83	.68	36.81	87.98
	B			.68	.32			51.17	
12	A	.37	.46		.17	2.75	.67	37.30	86.60
	B			.68	.32			49.30	
13	A	.43	.27		.30	2.49	.68	33.46	82.71
	B			.62	.38			49.24	
14	A	.44	.30		.25	2.75	.71	36.24	89.24
	B			.70	.30			52.98	

Note: The figures in columns under *Strategy* and *Negotiate* are the frequency of players selecting a specific strategy or initiating a negotiation, in any given round.

Table 3: Bet Overview

Round	Role	Round Bet 1				Round Bet 2			
		In-In	In-Out	In	Out	In-In	In-Out	In	Out
3	A			1.90	3.10	1.06	2.21		1.73
	B	1.63	1.60		1.77			2.27	2.73
4	A			2.08	2.92	1.22	2.14		1.63
	B	1.46	1.73		1.81			2.02	2.98
5	A			2.29	2.71	1.13	2.06		1.81
	B	1.27	1.84		1.89			2.05	2.95
6	A			2.40	2.60	1.21	2.32		1.48
	B	1.29	2.00		1.71			2.41	2.59
7	A			2.32	2.68	1.05	2.10		1.86
	B	1.48	2.00		1.52			2.48	2.52
8	A			2.14	2.86	1.14	1.89		1.97
	B	1.17	1.94		1.89			2.25	2.75
9	A			3.52	1.48	2.75	1.46		0.79
	B	3.30	1.25		0.44			3.65	1.35
10	A			3.32	1.68	2.54	1.67		0.79
	B	3.13	1.48		0.40			3.51	1.49
11	A			3.16	1.84	2.46	1.65		0.89
	B	2.73	1.59		0.68			3.08	1.92
12	A			3.06	1.94	2.48	1.70		0.83
	B	2.57	1.57		0.86			3.32	1.68
13	A			2.83	2.17	2.22	1.78		1.00
	B	2.22	1.78		1.00			3.13	1.87
14	A			2.71	2.29	2.10	1.81		1.10
	B	2.44	1.49		1.06			3.03	1.97

Note: The figures are the number of coins players bet on each option in any given round.

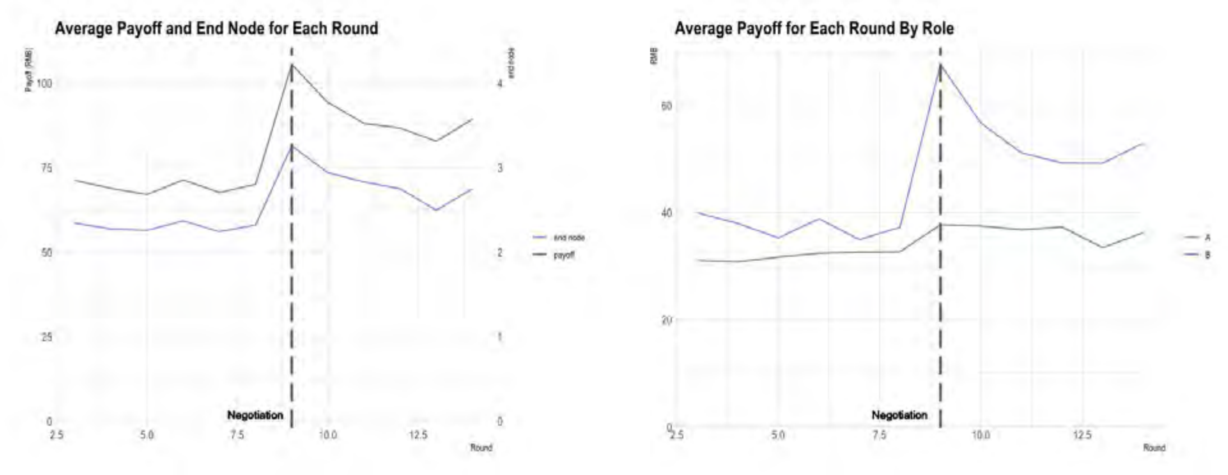

Figure 5: Payoff By Round and Role

welfare is affected by learning, the anxiety and avoidance scores of the players, and the introduction of the Negotiation Stage.

The average payoff and end node by round and role are shown in Figure 5. There is a clear increase in both the group payoff and the payoff for Player B after the introduction of the Negotiation Stage. At the seventh stage, the average end node of the game reaches above 3, which suggests that very few groups have chosen “Out” and many groups followed the most efficient plan as specified in the negotiation message. Since Player B is the biggest winner in the plan specified in the negotiation message, there is no surprise that Player B has a higher payoff than Player A. However, both the payoff and the end node declined gradually after the seventh round, suggesting the emergence of exploitation and distrust has driven down the cooperation level.

I then further investigate those relationships with a multiple linear regression model. The estimations are shown in Table 4. Consistent with our observations in Figure 5, negotiation significantly increases individual payoffs, end nodes, as well as group payoffs when it is initiated. This resolves our research question (iii). On the other hand, the payoffs, as well as end node decline as the game repeats, indicating a

Table 4: Payoff, End Node, And Total Payoff

	Dependent variable:					
	log(payoff)		end_node		log(total_payoff)	
	(1)	(2)	(3)	(4)	(5)	(6)
log(anxiety)	-0.253**	-0.283***	-0.431*	-0.489***	-0.380*	-0.447***
	(0.095)	(0.072)	(0.171)	(0.119)	(0.154)	(0.111)
log(avoidance)	-0.154	-0.029	-0.273	-0.141	-0.210	-0.037
	(0.101)	(0.075)	(0.195)	(0.135)	(0.155)	(0.114)
round	0.003	-0.011*	0.001	-0.034***	0.002	-0.012
	(0.012)	(0.006)	(0.023)	(0.010)	(0.013)	(0.006)
groupid	0.025	0.107**	-0.004	-0.003		
	(0.043)	(0.032)	(0.084)	(0.059)		
negotiate		0.408***		1.001***		0.433***
		(0.042)		(0.072)		(0.045)
bomb	-0.0001	-0.0004	-0.003	-0.003	-0.0005	-0.001
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
Constant	5.139***	4.844***	5.413***	5.676***	6.141***	5.905***
	(0.597)	(0.441)	(1.127)	(0.770)	(0.611)	(0.438)
Rounds	1 6	All	1 6	All	1-6	All
Observations	748	1,498	748	1,498	377	755
R^2	0.028	0.103	0.022	0.146	0.033	0.162
Adjusted R^2	0.013	0.096	0.008	0.139	0.023	0.157

Note: Ordinary least squares (OLS) estimates, robust standard errors in parentheses. Variable *groupid* has 1 for A and 2 for B. A control vector of demographic information is included. Log transformations were performed on selected variables. 2 observations (1 round) are removed because in that specific round one participant failed to make a choice in time. *p<0.05; **p<0.01; ***p<0.001

Table 5: Initiative to Negotiate

	Dependent variable:		
	negotiate		
	(1)	(2)	(3)
anxiety	-0.042*	-0.045*	-0.043
	(0.019)	(0.019)	(0.022)
avoidance	0.034	0.030	0.015
	(0.019)	(0.019)	(0.021)
round	-0.051	-0.051	-0.052
	(0.065)	(0.066)	(0.067)
bomb		0.009	0.010
		(0.005)	(0.006)
Constant	1.732	1.540	4.379
	(1.038)	(1.070)	(2.613)
Demographics	No	No	Yes
Observations	378	378	378
Log Likelihood	-226.866	-225.633	-222.042
Akaike Inf. Crit.	461.731	461.267	466.084

Note: Logistic model is used for estimation. All model applied robust standard errors. A control vector of demographic information is included. *p<0.05; **p<0.01; ***p<0.001

presence of learning towards Nash Equilibrium which aligns with previous experimental results in many game theoretic models (Rapoport et al., 2003; Gill and Prowse, 2016).

Concerning anxious attachment, individual payoffs are negatively impacted by anxiety in both the first six rounds and the last six rounds. Consistently, end node and group payoff are both negatively impacted by anxiety across all rounds. This suggests that the presence of highly anxious individuals tends to reduce the level of cooperation, damaging both individual profit and the efficiency of the outcome. In contrast, no significant relationship is identified between the avoidance score and the efficiency of the outcome.

3.3 Initiative to Negotiate

I am also interested in whether attachment has an impact on the initiative to negotiate. Only data from Player A in the last six rounds are included since only in this condition the option of negotiating is available. I fit a logistic model to examine the effect. The results are shown in Table 5. Anxiety predicts a reduced initiative to negotiate whereas avoidance has no significant impact. When I control for demographics, the result turns insignificant. Interestingly, risk preference has a significant impact on the initiative to negotiate, where risk-loving individuals are more likely to initiate the negotiation. No clear trend regarding the evolution of negotiation across rounds is identified. A possible explanation is that initiating a negotiation introduces more uncertainty as one has to guess not only the strategies and beliefs of their co-player but also whether their co-player would accept the offer and play the proposed strategy. Therefore, a risk-averse individual may tend to avoid that extra uncertainty.

3.4 Trust and Higher-order Trust

I get to directly examine the level of trust through the elicitation of first- and second-order beliefs. I define the level of first-order trust as the probability one assigns to the co-player playing the efficiency-maximizing strategy. For Player A, this is measured by the number of coins they placed on the option “In” in the first round of betting. Similarly, for Player B it’s measured by the number of coins they placed on “In-In”. The mutual trust between players and consequently the efficiency of outcome could be damaged if one constantly believed that their co-player did not trust them. Therefore it is also interesting to see if one has problems trusting their own “image” in their co-players’ eyes. Following the same logic, I define the level of second-order trust as the probability one assigns to the co-player believing *themselves* playing the efficiency-maximizing strategy, i.e. “In-In” for Player A and “In” for Player B, measured by the number of coins placed on those options. I created both first-order and second-order trust variables and see if they correlate to either or both attachments.

I fit an OLS model and present the results in Table 6. Both anxiety and avoidance significantly reduce one’s first-order trust. On the other hand, I examine if lack of trust caused reduced efficiency of outcomes in column (3). The results showed significantly negative impact of both first- and second-trust over the efficiency of game outcomes, with first-order trust causing more damage on the efficiency. Therefore I conclude that the lack of trust insecurely attached individuals had for their co-players was one of the potential reasons behind the damaged group welfare.

In addition, the role has a significant effect on the trust variables. I believe that it is due to the difference in the number of options. For the first round of betting, Player A has two options to bet on, compared with three for Player B. Therefore player B may on average place fewer coins on the trusting option simply because they have one

Table 6: First- and Second-Order Trust

	Dependent variable:		
	firsttrust	secondtrust	end_node
	(1)	(2)	(3)
anxiety	-0.018**	-0.005	
	(0.007)	(0.006)	
avoidance	-0.018**	-0.012	
	(0.007)	(0.007)	
firsttrust			0.194***
			(0.019)
secondtrust			0.143***
			(0.019)
bomb	-0.003	-0.004*	-0.001
	(0.002)	(0.002)	(0.001)
groupid	-0.503***	1.044***	-0.022
	(0.086)	(0.086)	(0.056)
round	0.004	0.019	-0.038***
	(0.016)	(0.016)	(0.009)
negotiate	1.335***	1.340***	0.559***
	(0.112)	(0.117)	(0.069)
Constant	4.783***	0.903	2.014***
	(0.761)	(0.738)	(0.133)
Observations	1,498	1,498	1,510
R^2	0.182	0.232	0.301
Adjusted R^2	0.176	0.226	0.299

Note: Ordinary least squares (OLS) estimates, robust standard errors in parentheses. A control vector of demographic information is included. 2 observations (1 round) are removed because in that specific round one participant failed to make a choice in time. *p<0.05; **p<0.01; ***p<0.001

more alternative to "distract" them. This is congruent with the second-order trust as in the second round of betting Player A has one more option than Player B, causing them to place on average fewer coins on the trusting option. It is also amazing to see that negotiation strongly increases levels of both first- and second-order trust, which fits the prediction of the motivated belief literature.

3.5 Stability of Cooperation

I evaluate the stability of cooperation with the longest streak of cooperative choices for each player. For player A, the cooperative behavior is to choose "In-In". For player B, the cooperative behavior is to choose "In". It is a quite important indicator of the stability of cooperation because if one cannot identify consistent intention to cooperate from the other player, then they are not able to form firm belief of the other, which will drive them to play the Nash Equilibrium strategy—the best choice if they know nothing about their co-player.

Figure 6 visualizes the regression model result. Anxiety is found associated with an average shorter cooperation streak, whereas no significant relationship is identified for avoidance. In simple words, players with an anxious attachment more easily stop cooperating when they were having an ongoing cooperation.

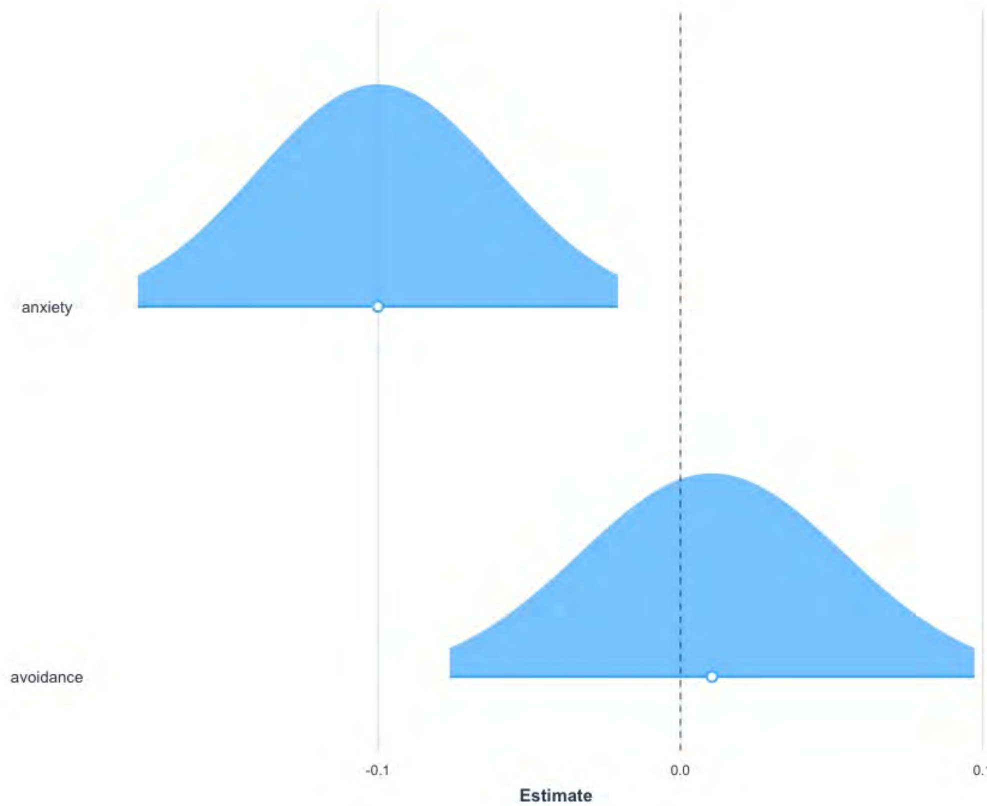

Figure 6: The Stability of Cooperation

Note: OLS model is used for estimation. All demographics and risk preference are used for control. The line in the middle marks the null hypothesis that no significant impact is identified. No overlapping between the distribution and the line indicates significant rejection of the null hypothesis.

4 Discussion

4.1 The Implications of Insecure Attachment

The results have shown that anxious attachment predicts lower individual payoffs, lower efficiency of outcome, lower trust level, lower stability of cooperation, and a lower initiative to cooperate, whereas avoidant attachment only predicts a lower trust level. I discuss below the possible explanations and implications of this result.

Anxious attachment, as mentioned previously, is related to a negative self-perception. The tendency to question whether they deserve a wholesome relationship can cause them to retreat early from the game, denying cooperation in the first place and leading to an inefficient outcome. As the game proceeds, the fear of being betrayed and dumped will make them less likely to maximize the group payoff when the co-player is seeking an efficient outcome. For example, a highly anxious Player B may choose to play "Out" whatsoever no matter how many times their co-player has played "In-In" and how strongly they believe their co-player will play "In-In" this round, because they are afraid that they will be abused by their co-player at some time with an "In-Out" deviation. Being cheated by the co-player contributes to a more hurtful feeling of being denied and even ignored, which results in considerable disutility for an already fragile self-image. This is supported by the results in Figure 6. Therefore, they will choose not to completely devote themselves to cooperation easily when the game is looking good and promising.

On the other hand, when the game is clearly not moving towards an efficient outcome, a highly anxious player will have a hard time claiming values and reviving cooperation by punishing their co-players due to their inclination to please others. The conflicts between anxiety about being betrayed and reluctance with disappointing others can cause them to practice "ill altruism", namely to They can constantly play

"In" when the co-player is playing "Out" to abuse them. This not only prevents an ill-fated game from being saved, but also drastically blocks the anxious players from gaining more profit.

When negotiation is made possible, anxiously attached players are less likely to initiate them. Given that negotiation considerably increases both the individual profit and group payoff, their reluctance to negotiate further hinders their earnings in the game. This effect can be attributed to the fear of being rejected. Similar to being cheated by their co-players, being rejected also inflicts severe damage on a fragile self-image. "If you are really afraid of rejection, then do not ask for anything" is likely the strategy those anxiously attached individuals adopted. However, this is terrible economic decision-making for it damages efficiency.

A possible explanation for the difference between the impact of anxious attachment and avoidant attachment on their initiative to negotiate is that the anxiously attached, due to their negative self-perception, possesses a mentality of "exploitation aversion". Taking a closer look at Figure 5, we see that cooperation dropped significantly quickly after it peaked around round 7 and round 8. This drastic decline was anticipated because the strategy pair proposed in the negotiation message was a huge deviation from the stable Nash Equilibrium. Player A should soon realize that choosing "In-Out" after tricking Player B into choosing "In" yields a higher payoff than honestly cooperating, thereby deciding to lie and exploit. Doing so is, however, particularly difficult for individuals with an anxious attachment, because the destined outcome of annoying their co-players and losing trust goes strongly against their needs for preoccupation. In comparison, this was not at all a problem, if not a bless, for the avoidantly attached, for their negative views of others and their tendency to distance others. As a result, participants with high anxiety scores are more likely than their avoidant counterparts to refrain from proposing the negotiation, especially when they do not want to cooperate in this round. This explanation is supported by analysis in Appendix C. Note that this does not take away the validity of the finding that anxiously attached individuals have a reduced initiative to negotiate, as the impact remains significant after taking into account the "exploitation aversion" in the analyses.

The results for avoidant attachment is more blurry. Contrary to anxious attachment, avoidant attachment predisposes people to perceive others with a more negative view. This possibly explains why avoidance predicts a low level of trust, as those with a high avoidance score may perceive their co-player as untrustworthy simply because they are inclined to depict others with a bad image. Consequently, the fact that highly avoidant players start the game with a strong tendency to distrust their co-players significantly drives them away from cooperating at the early stage and drags down the efficiency of the outcome.

One potential reason for the noisiness of the impact avoidant attachment has is that the environment we created activates anxious attachment more effectively than avoidant attachment. Though both are compatible in the context of close relationships, avoidant attachment requires an established relationship whereas anxious attachment does not necessarily do. Intuitively, an avoidantly attached can only start to avoid when they feel closely attached to, while an anxiously attached can start to feel anxious even before any real contact is made (Bowlby, 1988). This marks the fundamental difference between the activation of those two attachments in our experiment: for someone they do not know and do not meet, it is more easy to feel anxious than avoidant, given similar level of anxiety and avoidance. However, given the lack of statistical support, we avoid making any conclusion before further evidence is identified regarding avoidant attachment.

A potential way to conceptualize the role of attachment styles is to treat them as determinants of a novel type of social preference (Charness and Rabin, 2002). The anxiously attached individuals can be theorized as a type of players who award outcomes as results of cooperative behaviors, whereas the avoidantly attached are players who penalize such outcomes in terms of utility. The extent of those award/penalty is affected by and should be positively correlated with the extent of insecure attachments. This is distinct from the existing social preferences, i.e. altruism or fairness. Such exogenous preferences in theory can explain the distinct behaviors among the anxiously attached, avoidantly attached, and securely attached individuals, and further research on this topic could be carried out.

All of those reasons together account for the bad fortune of the highly anxious individuals. This has real-life implications from various angles. Firstly, the evidence that anxious attachment hurts individual profits in this centipede game contributes to the literature exploring the negative impact of anxiety on individual welfare. By showing that anxious people lead to a worse outcome in an economic game, I have contributed to the growing list of reasons for parents to put more emphasis on a healthy child-parental relationship. There is still a considerable number of parents who exert enormous pressure on their kids by asking them to learn numerous skills at an early stage of life, expecting them to be financially successful in the future. As it usually comes at a cost of a lack of company, affection, and intimacy, this way of parenting can adversely damage their kids' future in a economic way. Therefore, our results have a prospect for positive intervention in parenting. Moreover, since attachment styles are subject to change through proper intervention, from an Industrial-Organizational perspective, firms may want to invest in helping their employees develop a secure attachment style. Success in this can lead to better cooperation, higher work efficiency, as well as enhanced communications.

Bridging the two seemingly irrelevant literature, our study shows the potential of explaining behavior patterns and treatment effects widely studied in behavioral and experimental economics directly with established psychological theories. Joining in a relatively understudied literature (Gill and Prowse (2016); Dohmen et al. (2018)) for cognitive ability and character skills, I focus on understanding how individual differences impact the entire economic system, specifically in a game theoretic context. A richer understanding of this topic helps us develop more comprehensive models for both the environment and the player, which encompass the potentials for more accurate predictions and more efficient interventions.

4.2 Limitations and Future Directions

A main concern for the validity of this study is whether the activation of the attachment system is sufficient. Though I have tried my best to maximize the cognitive load in the centipede game, the stress may still not be enough to activate the behavioral system. A possible alternative is to utilize priming methods to create a "state attachment", which typically involves procedures like asking participants to recall a situation in which they felt anxious, avoidant, or comfortable depending on another person Yip et al. (2018). As mentioned above, I highly suspect that the activation of avoidant attachment is less effective than the one for anxious attachment. A more direct approach is to examine participant pairs who already established close relationships, in which attachment is guaranteed to exist. If possible, future research can adopt similar strategies to highlight the impact of attachment.

The message in the Negotiation Stage could be considered as a cheap talk (Crawford and Sobel, 1982). Little information is actually transmitted through the message due to the large conflict of interests between Player A and B. Since Player A can always deviate to "In-Out" to achieve a higher payoff, Player B should have little reason to believe that Player A will follow the plan, and should totally disregard the message. Then a babbling equilibrium exists and is identical to the original SPNE. A negotiation mechanism with more realistic costs and signaling power could lead to more telling results. In addition, due to the repeated nature of this game, participants may also take the information as a signal that could be carried over to the next rounds. Since it is not the focus of this paper, I did not rigorously analyze the effect of the cheap talk, but future studies can focus on the strong impact of this piece of information on the game outcome.

Also, the decision of implementing a repeated environment was made because I want to create an interactive relationship to better simulate the attachments in real life. If instead subjects are told that their co-players were different for each round, I hypothesized that they may not follow as closely with their attachment systems because there would be not enough time for them to form any attachment. However, it is also possible that the behavioral patterns as a result of the attachments were made default, which would be consistent no matter whether there is such an interactive relationship or not. Future studies may test whether the result is still robust if the co-players are constantly changing for each subject to test the above hypothesis.

Finally, the generalizability of this study needs more tests and research. I have picked the centipede game on purpose due to the reasons explained above, and it could be possible that our results are specific to the centipede game. Though I claim that such tendency will persist in a general situation where cooperation and complex thinking are involved, and studies like Taheri, Rotshtein and Beierholm (2018); Maranges, Chen and Conway (2022) showed support, more research is required to fortify this claim.

One of the possible future directions is to adopt a grouping methodology. Since the interaction between two insecurely attached individuals could exacerbate the collapse of trust and cooperation, future research can group the participants scoring above the sample median together and the participants scoring below the sample median together and use some cross-type groups as the baseline to see if the effect would be disproportionately more significant. Also, we can put the participants into more detailed groups. For example, it's not clear how individuals who score high on both Anxiety and Avoidance would behave, and this could be made possible by categorizing the participants into four pre-defined types.

4.3 Concluding Remarks

Taken together, our results revealed preliminarily the relationships between two kinds of insecure attachments and performance in a centipede game. Of foremost importance, negative consequences have been found regarding the efficiency of game outcomes, and potential reasons have been discussed. Given the astonishingly big population of insecurely, especially anxiously attached people around the globe, there is a prospect of improving social welfare by treating those insecure attachments. Undoubtedly, extensive research is needed beyond our preliminary study. More rigorous modeling and more sophisticated experimental design could potentially help produce more interesting results and research directions.

References

Ainsworth, Mary D. Salter, Mary C. Blehar, Everett Waters, and Sally Wall. 1978. *Patterns of attachment: A psychological study of the strange situation.* Oxford, England:Lawrence Erlbaum.

Albert, Lumina S., David G. Allen, Jonathan E. Biggane, and Qing (Kathy) Ma. 2015. "Attachment and responses to employment dissolution." *Human Resource Management Review*, 25(1): 94–106.

Archer, Marc, Miriam Steele, Jijun Lan, Xiaochun Jin, Francisca Herreros, and Howard Steele. 2015. "Attachment between infants and mothers in China: Strange situation procedure findings to date and a new sample." *International Journal of Behavioral Development*, 39(6): 485–491.

Ben-Ari, Rachel, and Itzhak Hirshberg. 2009. "Attachment Styles, Conflict Perception, and Adolescents' Strategies of Coping with Interpersonal Conflict." *Negotiation Journal*, 25(1): 59–82.

Bowlby, John. 1982. "Attachment and loss: retrospect and prospect." *The American journal of orthopsychiatry*, 52(4): 664–678.

Bowlby, John. 1988. *A Secure Base.* New York:Basic Books.

Brennan, K.A., C.L. Clark, and Phillip Shaver. 1998. "Self-report measurement of adult attachment: An integrative overview." *Attachment Theory and Close Relationships*, 46–76.

Camerer, Colin F., Teck-Hua Ho, and Juin-Kuan Chong. 2004. "A Cognitive Hierarchy Model of Games*." *The Quarterly Journal of Economics*, 119(3): 861–898.

Campitelli, Guillermo, and Fernand Gobet. 2010. "Herbert Simon's Decision-Making Approach: Investigation of Cognitive Processes in Experts." *Review of General Psychology*, 14(4): 354–364.

Carnelley, Katherine B., and Angela C. Rowe. 2007. "Repeated priming of attachment security influences later views of self and relationships." *Personal Relationships*, 14(2): 307–320.

Charness, Gary, and Matthew Rabin. 2002. "Understanding Social Preferences with Simple Tests." *The Quarterly Journal of Economics*, 117(3): 817–869.

Chen, Daniel L., Martin Schonger, and Chris Wickens. 2016. "oTree—An open-source platform for laboratory, online, and field experiments." *Journal of Behavioral and Experimental Finance*, 9: 88–97.

Crawford, Vincent P., and Joel Sobel. 1982. "Strategic Information Transmission." *Econometrica*, 50(6): 1431–1451.

Crosetto, Paolo, and Antonio Filippin. 2013. "The "bomb" risk elicitation task." *Journal of Risk and Uncertainty*, 47(1): 31–65.

Crosetto, Paolo, and Marco Mantovani. 2018. "Representation effects in the centipede game." *PloS one*, 13(10).

Dohmen, Thomas, Armin Falk, David Huffman, and Uwe Sunde. 2018. "On the Relationship between Cognitive Ability and Risk Preference." *Journal of Economic Perspectives*, 32(2): 115–34.

Falk, Armin, Anke Becker, Thomas Dohmen, Benjamin Enke, David Huffman, and Uwe Sunde. 2018. "Global Evidence on Economic Preferences*." *The Quarterly Journal of Economics*, 133(4): 1645–1692.

Fraley, R. Chris. 2002. “Attachment Stability From Infancy to Adulthood: Meta-Analysis and Dynamic Modeling of Developmental Mechanisms.” *Personality and Social Psychology Review*, 6(2): 123–151.

Fraley, R., Paula Niedenthal, Michael Marks, Claudia Brumbaugh, and Amanda Vicary. 2006. “Adult Attachment and the Perception of Emotional Expressions: Probing the Hyperactivating Strategies Underlying Anxious Attachment.” *Journal of personality*, 74: 1163–90.

Gao, Qianyun, Xuying Jia, Hanyue Liu, Xiuxin Wang, and Yongfang Liu. 2020. “Attachment style predicts cooperation in intuitive but not deliberative response in one-shot public goods game.” *International Journal of Psychology*, 55(3): 478–486.

García-Pola, Bernardo, Nagore Iriberri, and Jaromír Kovářík. 2020. “Non-equilibrium play in centipede games.” *Games and Economic Behavior*, 120: 391–433.

Gill, David, and Victoria Prowse. 2016. “Cognitive Ability, Character Skills, and Learning to Play Equilibrium: A Level-k Analysis.” *Journal of Political Economy*, 124(6): 1619–1676.

Gunia, Brian C., Roderick I. Swaab, Niro Sivanathan, and Adam D. Galinsky. 2013. “The Remarkable Robustness of the First-Offer Effect: Across Culture, Power, and Issues.” *Personality and Social Psychology Bulletin*, 39(12): 1547–1558. PMID: 23950554.

Hao, Jichun, Raymond Chan, and Ross Wilkinson. 2019. “A Cross-Cultural Examination of the Experiences in Close Relationships — Revised — General Short

Form (ECR-R-GSF) in an Australian and a Chinese Sample." *Journal of Relationships Research*, 10.

Holt, Charles A., and Susan K. Laury. 2002. "Risk Aversion and Incentive Effects." *American Economic Review*, 92(5): 1644–1655.

Kawagoe, Toshiji, and Hirokazu Takizawa. 2012. "Level-k analysis of experimental centipede games." *Journal of Economic Behavior & Organization*, 82(2): 548–566. Emergence in Economics.

Lee, Sujin, and Leigh Thompson. 2011. "Do agents negotiate for the best (or worst) interest of principals? Secure, anxious and avoidant principal–agent attachment." *Journal of Experimental Social Psychology*, 47(3): 681–684.

Lehto, Anna-Maija. 2013. "Time Pressure as a Stress Factor." *Loisir et Société / Society and Leisure*, 21: 491–511.

Lejuez, C.W.and Aklin, Will M., Michael J. Zvolensky, and Christina M. Pedulla. 2003. "Evaluation of the Balloon Analogue Risk Task (BART) as a predictor of adolescent real-world risk-taking behaviours." *Journal of Adolescence*, 26(4): 475–479.

Levitt, Steven D., John A. List, and Sally E. Sadoff. 2011. "Checkmate: Exploring Backward Induction among Chess Players." *The American Economic Review*, 101(2): 975–990.

Li, Yuanyuan Jamie, Su Lu, Junmei Lan, and Feng Jiang. 2019. "Feel Safe to Take More Risks? Insecure Attachment Increases Consumer Risk-Taking Behavior." *Frontiers in Psychology*, 10.

Maranges, Heather M., Susan K. Chen, and Paul Conway. 2022. "Insecure and insensitive: Avoidant and anxious attachment predict less concern for others in sacrificial moral dilemmas." *Personality and Individual Differences*, 185: 111274.

McKelvey, Richard D., and Thomas R. Palfrey. 1992. "An Experimental Study of the Centipede Game." *Econometrica*, 60(4): 803–836.

McKelvey, Richard D., and Thomas R. Palfrey. 1995. "Quantal Response Equilibria for Normal Form Games." *Games and Economic Behavior*, 10(1): 6–38.

McKelvey, Richard D., and Thomas R. Palfrey. 1998. "Quantal Response Equilibria for Extensive Form Games." *Experimental Economics*, 1(1): 9–41.

Mikulincer, Mario, and Phillip R. Shaver. 2007. "Boosting Attachment Security to Promote Mental Health, Prosocial Values, and Inter-Group Tolerance." *Psychological Inquiry*, 18(3): 139–156.

Mikulincer, Mario, and Phillip R. Shaver. 2012. "Adult Attachment Orientations and Relationship Processes." *Journal of Family Theory & Review*, 4(4): 259–274.

Mikulincer, Mario, and Phillip Shaver. 2003. "The Attachment Behavioral System In Adulthood: Activation, Psychodynamics, And Interpersonal Processes." *Advances in Experimental Social Psychology*, 35: 53–152.

Palacios-Huerta, Ignacio, and Oscar Volij. 2009. "Field Centipedes." *American Economic Review*, 99(4): 1619–35.

Pinquart, Martin, Christina Feußner, and Lieselotte Ahnert. 2013. "Meta-analytic evidence for stability in attachments from infancy to early adulthood." *Attachment & Human Development*, 15(2): 189–218. PMID: 23210665.

Ponti, Giovanni. 2000. "Cycles of Learning in the Centipede Game." *Games and Economic Behavior*, 30(1): 115–141.

Prior, Vivien, and Danya Glaser. 2006. *Understanding attachment and attachment disorders: Theory, evidence and practice.* Jessica Kingsley Publishers.

Rapoport, Amnon, William E. Stein, James E. Parco, and Thomas E. Nicholas. 2003. "Equilibrium play and adaptive learning in a three-person centipede game." *Games and Economic Behavior*, 43(2): 239–265.

Rosenthal, Robert W. 1981. "Games of perfect information, predatory pricing and the chain-store paradox." *Journal of Economic Theory*, 25(1): 92–100.

Smead, Rory. 2008. "The Evolution of Cooperation in the Centipede Game with Finite Populations*." *Philosophy of Science*, 75(2): 157–177.

Taheri, Maliheh, Pia Rotshtein, and Ulrik Beierholm. 2018. "The effect of attachment and environmental manipulations on cooperative behavior in the prisoner's dilemma game." *PLOS ONE*, 13(11): 1–17.

Wang, Yun. 2022. "Belief and higher-order belief in the centipede games: An experimental investigation." *Pacific Economic Review*, 1–47.

Wilkinson, Ross B. 2011. "Measuring Attachment Dimensions in Adolescents: Development and Validation of the Experiences in Close Relationships — Revised — General Short Form." *Journal of Relationships Research*, 2(1): 53–62.

Yip, Jeffrey, Kyle Ehrhardt, Hunter Black, and Dayna O. Walker. 2018. "Attachment theory at work: A review and directions for future research." *Journal of Organizational Behavior*, 39(2): 185–198.

Zauner, Klaus G. 1999. "A Payoff Uncertainty Explanation of Results in Experimental Centipede Games." *Games and Economic Behavior*, 26(1): 157–185.

Appendix A Risk and Attachment

This section will mainly analyze the relationships between risk preferences and attachments, as an attempt to replicate the previous study done by Li et al. (2019). I categorized participants into two groups: secure and insecure[7]. There are in total 39 secure and 87 insecure individuals, a distribution which is comparable to the one in Li et al. (2019). The distributions are shown in Figure 7. A one-way ANOVA finds no significant differences between the insecure (M = 52.61, SD = 21.25) and secure (M = 46.92, SD = 20.03) groups ($F(1,126) = 1.41$, $p = 0.16$). Our results fail to support the previous findings.

Multiple reasons are possible for this result. The main measurement for attachment scales I used (ECR-R-GSF) is different from the one used in Li et al. (2019) (ECR), despite the similarity between them. The way I measure risk preferences is also very different. While I measured general risk preference with a bomb game, Li et al. (2019) asked the participants how likely they would be willing to try a new product/experience, which is mainly consumption driven. It's also different that I adopted an incentive-compatible measure, whereas they didn't. Therefore, I can only conclude that there are no robust relationships between risk-loving tendencies and insecure attachments in general, taking into consideration all the limitations of this study.

Appendix B Uneven Session Size Effect

One potential concern was that if the participants came in pairs and the session was small enough, there was a nonnegligible chance that they knew each other beforehand

[7] I follow the design by Li et al. (2019), by putting individuals who scored above 30 on either scale as insecurely attached and individuals who score below 30 on both scales as securely attached. The analysis also follows the original analysis to make the results as comparable as possible.

Figure 7: Risk Preferences: Insecure v.s Secure
Note: 0 indicates the insecure group, and 1 indicates the secure group. I compare the mean choice of number of boxes to open in the bomb game for the two groups.

and would change their behaviors in favor of their co-players as a consequence, despite knowledge that the pairing was completely random. In this section, I show that the size of the session had no significant impact on the efficiency of outcome.

3 sessions out of 12 had only 4 participants and 5 had only 6 participants. The rest have at least 8 participants. If the collusion among acquaintances is indeed an issue, then aggregate group payoff for the participants should be higher in sessions with fewer participants. I first showed with Fisher's test that no heteroskedasticity is identified between the two groups ($F = 1.03$, $p = 0.68$). An independent t-test assuming equal variance showed no significant differences between the small ($M = 1104.69$, $SD = 250.82$) and big ($M = 1103.24$, $SD = 261.93$) groups ($t(38.59) = 0.02$, $p = 0.98$). The results are also shown in Figure 8. Therefore, worries about the confounding impact resulted from unequal session sizes are resolved.

Appendix C Exploitation Aversion

This section addresses the hypothesis that anxious attachments predict less exploiting behaviors after negotiation is made possible, thereby further decreasing the likelihood of them choosing to send the negotiation message. Figure 9 shows the estimated impact of anxiety and avoidance scores over frequency of exploiting behaviors, confirming this hypothesis.

Appendix D Centipede Game Experiment Instructions

Below are the instructions participants saw on their screens. Because the content was different for Player As and Player Bs, I italicized the content that is *only* displayed

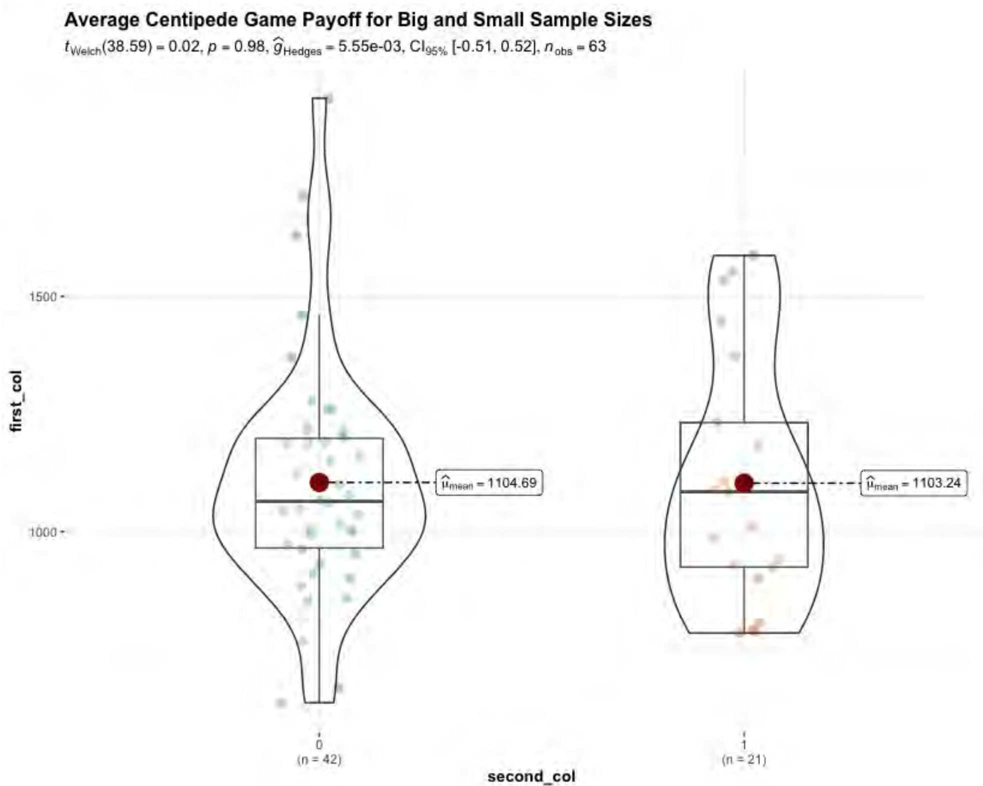

Figure 8: Session Size Effect: Small v.s Big

Note: 0 indicates the group of sessions that have more than 8 participants, and 1 indicates the group of sessions that have less than or equal to 8 participants. I compare the mean of the aggregate group payoff of each group, which was calculated by adding up all the total payoffs for the group across all 12 rounds.

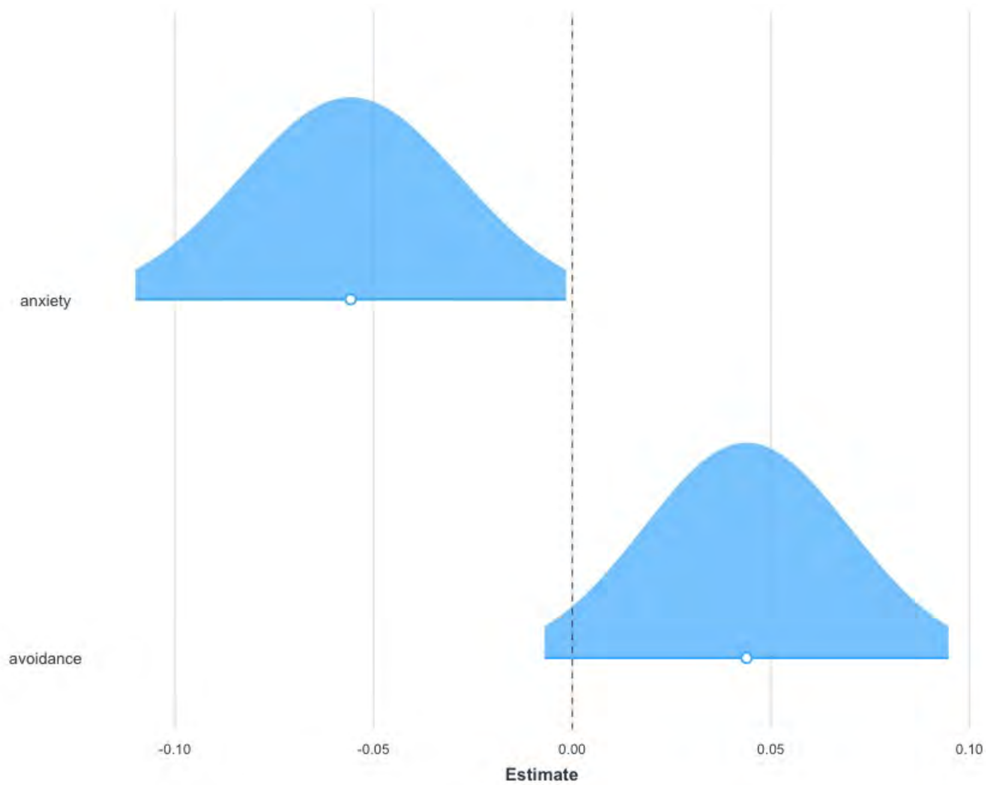

Figure 9: Exploitation Aversion for Anxiety and Avoidant Attachments
Note: OLS model is used for estimation. The dependent variable is acquired through transformation of data of all player A's behaviors. If at any given round, player A sent the negotiation message but did not follow the specified strategy, then they were marked "explotitative" for that round.

to Player A or Player B. Content not italicized was displayed to both Player A and Player B.

D.1 Introduction

Welcome, and thanks for participating in this experiment! This is a behavioral economics experiment. In this experiment session, you will take part in 14 rounds of two-player activities, where you will be paired with another player. The first two rounds will be trial rounds, which will not affect your final compensation. The instructions will be shown only once during the pilot round. The compensation you will earn at the end of the session is highly dependent on the quality of your understanding of the game and your judgements. So please take each round seriously, and stay keen and smart.

At the end of the session, we will calculate your compensation in the following way:

1. The payoff of each round is the sum of the coins you get for both stages
2. Each coin is equivalent to **2.5** RMB, and will be automatically exchanged to RMB at the end of the session
3. First, we will disregard the four rounds you've earned most
4. Second, we will disregard the four rounds you've earned least
5. Then we calculate the average of the remaining four rounds, which gives your final compensation

Your decisions and your final compensation will be kept confidential. Please make decisions without consulting anybody else. Talking to any other participant in your session is strictly prohibited. If you have any question at any time, you can text the experimenter privately.

Good Luck!

D.2 Role Assignment

For Player A:

*There are two roles in this activity, player A and player B. You are assigned the role **A** in this activity. Please note that this role assignment will not change throughout the activity.*

For Player B:

*There are two roles in this activity, player A and player B. You are assigned the role **B** in this activity. Please note that this role assignment will not change throughout the activity.*

You will engage in a two-player activity with the structure on the next page. For the first six rounds, you will play the activity with the same rules and structures, while there will be a new rule added to the activity for the last six rounds. This rule will be introduced after you finish the first six rounds of activities.

D.3 Activity Structure

Please first take a moment to understand the following structure. This is a choice-based activity, where each player has two choices when she is called to act. The letter at the top of each node indicates the player who needs to act. Player A has to make two choices at two different nodes, and Player B only has to make one choice. If the session proceeds to a branch with numbers below, then the session ends. Player A will get the **red** payoff written on **top**, and Player B will get the **blue** payoff at the

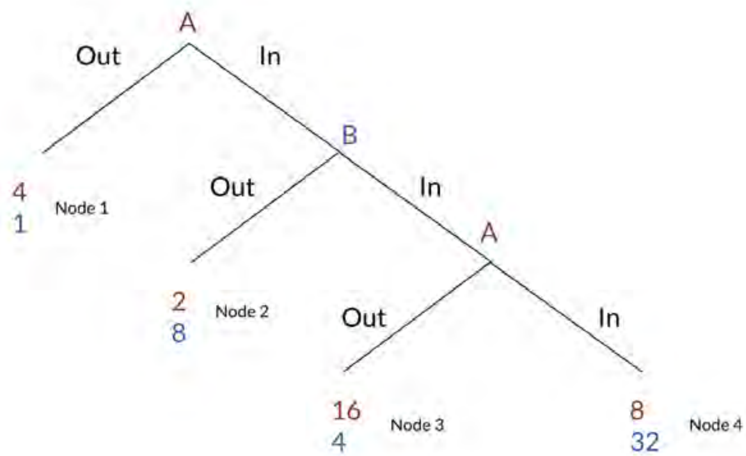

Figure 10: Activity Structure

bottom. The unit is in **coins**.

For example, player A has to start the session by making choices between "In" and "Out". If player A chooses "Out", then the round ends, with A getting 4 and B getting 1. If player A chooses "In", then Player B is called to choose from "In" and "Out". Similarly, if B chooses "Out", then the round ends and Player A gets 2 whereas Player B gets 8. Player B can also choose "In" and let the game proceed to the next stage, where A makes her final decision.

D.4 Your Choice – Instructions

Your task in this game is to make choices and predictions. This consists of two stages: the "Play Stage" and the "Bet Stage".

For Player A:

In the "Play Stage", you have to specify a strategy that you want to play in the next round. As player A, you have at most two choices to make. Therefore, you have to choose from the following three options:

1. ***"Out"*** *: Choose "Out" at the first node*

2. ***"In-Out"****: Choose "In" at the first node, and choose "Out" when the round proceeds to the third node*

3. ***"In-In"****: Choose "In" at the first node, and choose "In" when the round proceeds to the third node*

For Player B:

In the "Play Stage", you have to specify a strategy that you want to play in the next round. As player B, you have at most one choice to make. Therefore, you have to choose from the following two options:

1. ***"Out"*** *: Choose "Out" at the second node if the game proceed to that node*

2. ***"In"*** *: Choose "In" at the second node if the game proceed to that node*

After you make your choice, your strategy will be automatically played by the program. You have 60 seconds to decide your strategy. Failure to choose will result in zero payoff.

D.5 Bet – Instructions

In the "Bet Stage", you will be asked to predict the choices of the other player. There are two rounds of betting in this stage, and you will have 5 free coins for each round. Each handicap will last for 60 seconds. You must use up all coins to place your bet, or else you will get **zero coin** for this entire round. You can freely allocate your coins in the way you believe that is most profitable. The bet pays 1 to 1.

After you have placed your bets, we will calculate how many coins you have got. The most you can get in this stage is 10 coins.

D.6 Bet Round 1 – Instructions

For Player A:

In this round, we want you to predict what Player B chose in the "Play Stage". Note that since Player B can at most act once, their choice is limited to "Out" and "In":

1. ***"Out"**: Choose "Out" at the second node*
2. ***"In"**: Choose "In" at the second node*

For example, if Player B has chosen "Out" in the first round and you bet all 5 coins on "Out", you get 5 coins for this round. If instead you bet 3 coins on "Out" and 2 on "In", then you get 3 coins in this round.

For Player B: *In this round, we want you to predict what Player A chose in the "Play Stage". Note that since Player A can at most act twice, they have three potential choices:*

1. ***"Out"** : Choose "Out" at the first node*
2. ***"In-Out"** : Choose "In" at the first node, and choose "Out" if the game proceeds to the third node*
3. ***"In-In"** : Choose "In" at the first node, and choose "In" if the game proceeds to the third node*

For example, if Player A has chosen "In-Out" in the first round and you bet all 5 coins on "In-Out", you get 5 coins for this round. If instead you bet 3 coins on "In-Out", 1 on "Out" and 1 on "In", then you get 3 coins in this round.

Place your bets (you have 5 coins in total, the numbers in all of the fields **must** add up to 5, or you will get 0 payoff this round). Each coin placed on the correct option will pay 1 coin back to you.

Good Luck!

D.7 Bet Round 2 – Instructions

For Player A: *In this round, we want you to predict how Player B has predicted your choice. We have asked player B in the first betting round to predict whether you have chosen "Out", "In-Out", or "In-In" in your "Play Stage".*

Remember that the closer your bet matches the exact distribution of Player B's bet, the higher payoff you get. For example, if in the first round of betting, Player B has bet 3 coins on you choosing "Out", and 2 coins on you choosing "In", then you will get 5 coins if you bet 3 on "Out" and 2 on "In" in this round, but only 3 coins if you bet all 5 coins on "Out", and 0 coin if you bet all 5 coins on "In-Out". So aim to replicate how player A bet in the previous round of betting! So aim to replicate how player B bet in the previous round of betting!

For Player B:

In this round, we want you to predict how Player A has predicted your choice. We have asked player A in the first betting round to predict whether you have chosen "Out" or "In" in your "Play Stage".

Remember that the closer your bet matches the exact distribution of Player A's bet, the higher payoff you get. For example, if in the first round of betting, Player A has bet 3 coins on you choosing "Out", and 2 coins on you choosing "In", then you will get 10 coins if you bet 3 on "Out" and 2 on "In" in this round, but only 3 coins *if you bet all 5 coins on "Out". So aim to replicate how player A bet in the previous round of betting!*

Good Luck!

Only Displayed at Round 3

Caution! You have finished the two trial rounds. The next 12 rounds will start to affect your payoff. Good Luck!

D.8 Negotiation – Instructions

Congratulations for successfully completing the first seven rounds of the game! Now we are going to add a new stage to the game, the Negotiate Stage. This change will not affect any of your past results, and will apply to the end of the entire section. Below is the specific rule:

For Player A:

Now, before each round of game starts, you are given a choice to initiate a negotiation. You will have a chance to press a "negotiate button". If you decide to press that button and start negotiation, the following message will be automatically sent to player B:

Let's cooperate, I will play "In-In", please play "In"

Then the game proceeds the same way it was in the past seven rounds. Note that you may or may not follow the plan specified in this message if you press the button.

For Player B:

Now, before the start of each round, you may receive a message from Player A. The other parts of the game will stay the same.

D.9 Results

In round X,

Player A has chosen XX,

Player B has chosen XX,

This round ended at X,

Adding your earnings in betting rounds, you earned XXX.

D.10 Bomb Game Experiment Instructions

This section will reveal the result of the bomb game you played during the sign-up process. You decided to open **XX** boxes. Now we will use a randomizer to decide where is the bomb. We will generate a number from 1 to 100 with equal probability to label the bomb. If the label of the bomb is bigger than the number of boxes you decided to open, then you are safe and get **XX** RMB. Otherwise, the bomb will explode and you get nothing. Click "Next" to see the result!

The bomb is in box XX, you decided to open XX boxes.

You get XX RMB. This will be added to your total payoff.

Congratulations on finishing the entire session! Your total payoff is XX RMB.

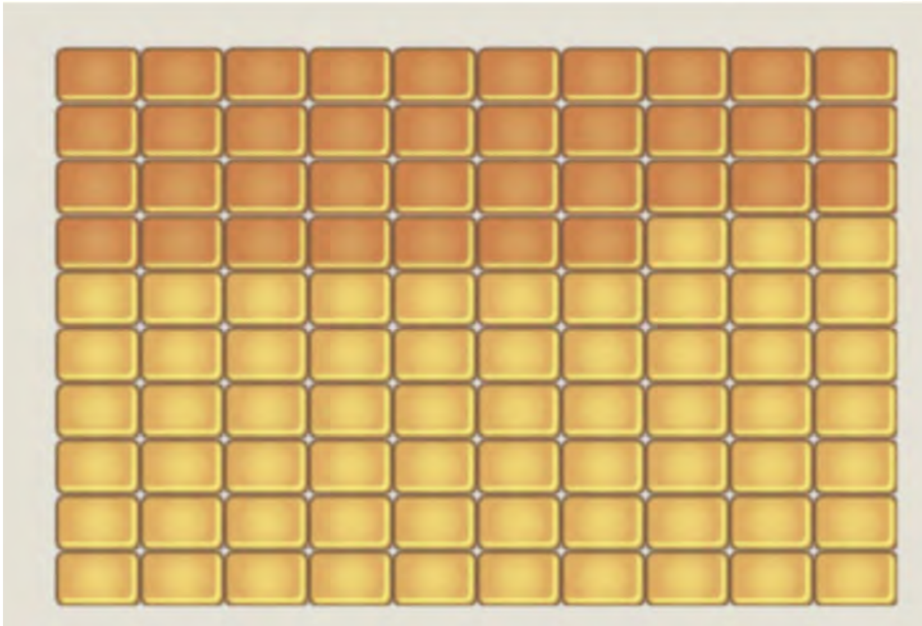

Figure 11: Bomb Game

Acknowledgement

When I wrote the proposal for this project in April, 2022, I was just a rookie researcher who barely knew how to carry out a serious academic project. I did not anticipate to have grown this much during just one years time. This work would not be possible without my advisor, Adam, who has been providing constant care and support for this project, but more often for me as a naive student, a stressed-out grad school applicant, and a kid who dreams of becoming an academic. Academically speaking, I received the most crucial help from Professor Xiangdong Qin, who offered numerous critical advice and opinions for my experimental design. I could not have undertaken this journey without the coordination from Professor Wendy Jin, who also kindly supported this project as the faculty investigator. Here, I take this opportunity to express my heartfelt gratitude to everyone mentioned above.

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