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Assignment Two – Cooperative Games

Question One

A) move():

Initially, a strategy would be to give coins to another player and see if they give back upon the next turn. If a player gives coins back on the next turn, then give them coins again, otherwise give coins to any other player who gave coins to the agent. If the agent receives no coins, it attempts to give coins to new players and only starts giving coins back to a player repeatedly if they give coins to the agent repeatedly. This strategy works since it is an example of the Bach or Stravinsky with N-players, where a Nash equilibria (a solution) forms when both players cooperate.

B) invest():

If the agent has a p-card, the agent should invest as much as possible since there is no risk of losing everything, and there is an exponential increase in returns with increasing investment. Since coordination is not allowed, we can follow a *smart status* strategy – as seen in the paper – where we attempt to invest in the player with the most emojis and only invest in emojis when the agent has been invested in during the previous round. Status is the amount of influence other players in the game are giving us, and durable inequalities – as exemplified above – causes the influences from status to be locked in place.

C) share_winnings():

Splitting the earnings evenly amongst players is suitable for a winning player. As the sharing of winnings is an example of the ultimatum game amongst all players, multiple solutions can be considered; one where all players share fairly, one where all share unfairly, and one where all players share unfairly but accept all other players who cooperate. In this agent, the agent will always share coins evenly with other players who share evenly but will share winnings unfairly when other players share unfairly.

D) purchase():

Players can purchase emojis at the end of the game to enforce a means of communication with other players. The agent will only invest in emojis if it has received coins from other players in the last round, which gives protection against the event that all players have the same number of emojis during the investment stage. If the agent estimates it can keep its card, a p-card should also be purchased at the end of the round. For randomness, the agent should give its coins to a random player with a probability of 5%.

Question Two

The moves in the game are like the Bach or Stravinsky game from game theory with N-players, where a Nash equilibria (a solution) forms when both players cooperate. During the first turn, we do not know how other players will operate or how they will choose to invest, nor do we know their agenda because there is no communication at this stage of the game. Not investing in someone can negatively impact status throughout the game as our agent would be giving an unfair offer to the other players (which is something they will remember). However, other players can take two coins and come out on top early. The number of turns in the game (or the size of the central bank if activated) dramatically changes the results of the first move. In a game with many turns or a large central bank, there is no need to take the first two coins since status matters a lot. However, if the game is short or has a small central bank, status is irrelevant since it will not matter how much the agent takes. Status matters since starting with a poor status can result in other players giving unfair shares of the winnings later, as one could expect in an ultimatum game. Starting with poor status can therefore impact the player for the rest of the game. The game can be portrayed as a Bach or Stravinsky game where the best thing to do would be to cooperate with another player if the game is going to run for many rounds or to take and hope another player will cooperate with the agent if there are a short number of rounds. Below is a sample table of a Bach or Stravinsky game where the size of a number represents the amount of reward received (in this case, coins received) for action for each player:

	Bach	Stravinsky
Bach	2, 1	0, 0
Stravinsky	0, 0	1, 2

Note: the rows represent player one and the columns represent player two.

Therefore, there are two equilibrium states that the agent can choose from in the setup elaborated upon above. In the first equilibrium state, the agent goes with its own goal – in this case, it takes the coins for itself – and another player tags along because it is better to cooperate than having no investment partner. In the other state, the agent goes with a partner's goal – in this case, it invests coins in the partner – and the partner invests back to tag along. Both strategies cause the agent and its partner (another player) to gain a point since they both cooperate for the remaining turns, but if the player manages to keep to coins for itself and have another player invest in it, it comes out one point on top. To figure out if the agent should be *greedy* and keep its coins, or should give coins to another player, multiple constraints such as the length of the game in the number of turns allowed/size of the central bank, along with the total number of coins which can be invested can be further considered when determining between the two equilibriums. A final strategy can be used as a middle ground when the agent cannot determine which of the two strategies to choose. In the third equilibrium, the agent can choose to take the coins for itself within a 60% probability. If other players use a similar policy, an optimal state can be reached across multiple starts.

The policy I would choose for the AI can be summarized as:

- if the number of rounds is in the game is tiny, take the two coins
- if the number of rounds in the game is high, give the two coins
- if the number of rounds in the game is medium, there is a 60% chance of keeping the coins and a 40% chance of giving the coins