Exploring the Game Theory and Nash Equilibrium in Love Relationships

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Regarding the individual action patterns and social behaviors, this paper studies the trajectories of individuals and groups in romantic relationships. Through simulations involving single individuals, pairs, trios, and groups, the trajectories and patterns have been discovered. The effectiveness of the method was verified in the real world.

Nash Equilibrium | Game Theory | Love Relationship

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Love has been extensively studied in both psychology and game theory. Many apps have been applied in the context of dating and relationships. For instance, QINGTENG ZHILIAN and Hinge. Some games incorporate elements of romance, such as Galgame.

Romantic love is the discrete, interrelated emotion/motivation systems that all birds and mammals have evolved to direct courtship, mating, reproduction, and parenting (1). We are looking for that which will enhance a greater sense of purpose and direction, and lend a trustworthy hand in times of our human trials (2). Love is about seeking a more complete self.

It has been discovered that there is a game-like phenomenon in love, and it is hypothesized that a Nash equilibrium might arise during the process of love. In this regard, this article conducts a study on the process of love, exploring the game theory and Nash equilibrium in love relationships.

Results

We found that there are generally four situations between two individuals.

- A. One party makes the effort, while the other party does not.
- B. The two people are attracted to each other or have common interests.
- C. Dislike or opposition arising from interests.
- D. Parallel relationship. The two have either the same or different goals. Even if they interact, it does not affect their trajectories.

We would prefer situation D, because it can facilitate the mutual growth of both parties. In this article, we discussed the game theory and Nash equilibrium in love relationships, and discovered the following Nash equilibrium:

- A. Remaining unchanged is the Nash equilibrium point.
- B. Mutual restraint. A can restrain B, and B can command A.
- C. The two individuals regarded each other as being more competent than themselves.
- D. Two individuals are interdependent. specifically, A can meet B's needs, and A needs B. The same applies to B.
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We point out that the game in a relationship is not static and can change at any time due to certain factors. Therefore, theoretically, there is no optimal situation. No matter which strategy we choose, we hope to let things take their natural course and find the path that suits us. Every individual is a passing guest in the cycle of life—please cherish and enjoy it.

Discussion

Among various emotions such as family affection, friendship and love, we choose to discuss love.

Ethics. We enjoy exploration and exploitation, anticipate challenges and problems, and leave the future to Clone (3).

- When things are not natural, do we resort to violence or experimentation?
- Thieves will be sentenced for stealing, but giving money legally while stealing will not result in a penalty.
- Return to one's hometown or choose the place where one has worked hard?
- As one's material and spiritual needs are met, how to maintain a happy life.

The best method currently known is Swarm Intelligence. unfortunately, we have not yet implemented it.

Resurrection and Longevity. People's pursuit of immortality stems largely from a fear of death and the passage of time.

Significance Statement

Due to the abundance of dimensions and the fact that they can be interchanged among each other, we consider this system to be cyclic.

Please provide details of author contributions here.

Please declare any competing interests here.

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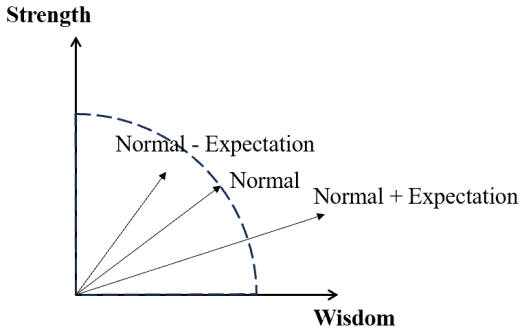


Fig. 1. Relationship between profits and expectations.

When it comes to death, we must recognize that beyond death lies only the wilderness. As for the passage of time, we must maintain a sense of purpose and progress.

Conclusions

Stable two-individual or three-individual systems are extremely rare.

Materials and Methods

In 1980, political scientist Robert Axelrod initiated Axelrod's Tournament: He invited experts from various fields to submit strategy programs, allowing them to compete against each other in a repeated prisoner's dilemma environment, in order to observe which strategies would be more likely to win in long-term interactions (4). This competition, known as Axelrod's Tournament, later became one of the most classic experiments in game theory. The result was that the TIT FOR TAT strategy emerged as the champion at that time. Its strategy was to cooperate in the first round and then replicate the previous round's choice of the opponent.

Single entity system. Inspired by Axelrod's Tournament, we discuss the issue in a simple scenario: Two people with basically the same conditions come across a piece of food. After sharing it, one of them may receive a larger portion while the other receives a smaller one. Those who obtain a larger portion are stronger. In the next instance, they might tend to fight for food with their bodies. Those who got a smaller share of the resources gained experience. In the next round, they might rely more on their intelligence to compete for food. After several such actions, their physical strength and intelligence reached a certain level.

Expectation factor. During this process, a situation may arise where expectations are generated due to the attraction of a certain desire. The Figure 1 illustrates the relationship between profits and expectations. We believe that under certain expectations, after a period of development, we reach a normal state. When attracted by desires, it may be positively motivated, thereby enhancing its own value; or it may go astray and ultimately its own value may even decrease.

Make efforts. At a certain stage, when an individual's goals have all been achieved, progress and effort can no longer be driven by the pursuit of goals. DeepSeek proposes a method of maintaining goals as a long-term state. A more dynamic approach involves compressing the past and present—since most tasks are accomplished through collaboration with other

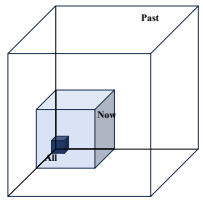


Fig. 2. Example of effort method.

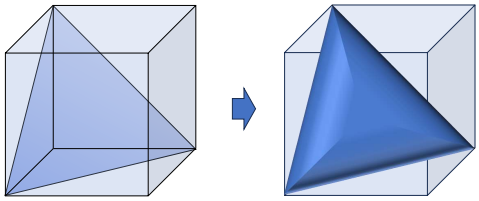


Fig. 3. Example of effort method.

individuals—and integrating them with current activities into the deep blue cube shown in Figure 2. The light blue section represents tasks yet to be completed, providing a space where we can fully exert our potential. By compressing the present, past, and future tasks into the deep blue cube, we can achieve a cyclical process.

There is another scenario. When the environment is relatively small, all tasks can be completed; however, upon moving to a larger environment, the sheer volume of work makes it difficult to complete the tasks, and it becomes challenging to evaluate the effort based on the amount of work accomplished. In this case, we can trim the search space once, as shown in the left portion of Figure 3, and then base our efforts on this cross-section, using the height of the protrusion as the new standard for evaluating effort.

Mobility factor. As shown in the Figure 4, it presents an example of the mobility of Alice and Bob. Before the interaction occurred, Alice had more Strength, while Bob had more Wisdom. After the interaction occurred, the value shifted. Alice saw a significant improvement on Wisdom, while Bob enhanced Strength. Of course, this situation is not inevitable. It is possible that after the interaction, Alice strengthened her Strength, while Bob strengthened her Wisdom.

Pattern factors(e.g. regulations). Each individual gradually forms a relatively fixed pattern through interaction with the environment, which results in the actions of the individual

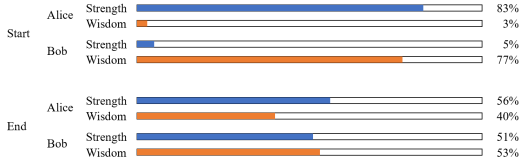


Fig. 4. Example of two-person mobility.

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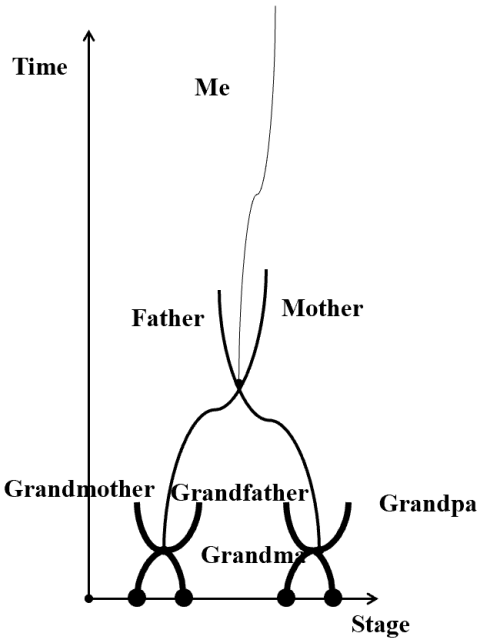


Fig. 5. Example of two-person mobility.

being predictable when encountering a certain situation.

Attractive factors. Individuals are drawn towards the advantages or novelty of other individuals, resulting in a tendency to approach or surround each other, thereby influencing the original trajectory. As time goes by, individuals gradually demystify the individuals who are attractive, and the trajectory returns to normal.

Growth factors. The Figure 5 shows axes of the growth.

Environment factors.

- Due to limitations in cognition or age, an individual's scope of life is narrowed down to a single neighborhood, while daily needs consume time, or expanded to cover the entire country, with commuting taking up time.
- The distance from different individuals or positions affects an individual's behavior.
- As time goes by or the environment changes, the demand-oriented approach transforms into a survival-oriented approach.

Conflict factors. Based on the previous behavioral trajectory, the actions that have been performed are prohibited, forming a conflict area. The remaining time can only be spent on taking actions within the available action space. The Figure 6 shows conflict action space.The red area represents the conflict zone, the dark blue area indicates the actions that have been taken but are not part of the conflict zone, and the light blue area represents the unacted-on areas that can be selected.

Born and death. An individual's journey from formation to annihilation—for example, a person's journey from birth to death. If death is the end point, then the purpose of life is to prevent death; we take greater care of ourselves or reduce our activities to delay ageing, because our motivation stems

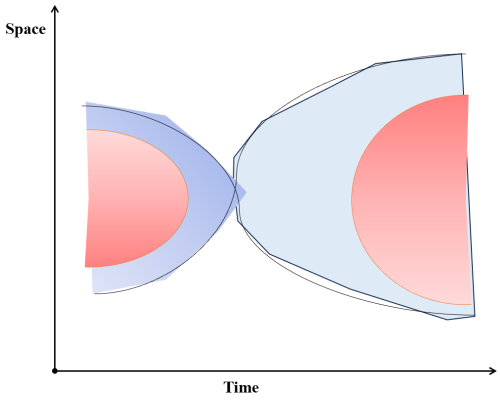


Fig. 6. Example of two-person mobility.



Fig. 7. Example of born to death condition 1.

from death, as illustrated in Figure 7. Viewed from another perspective, apart from death, the rest of the spectrum is life; the existence of death implies the existence of a wilderness, where we can grow freely and without constraint, as shown in Figure 8. There's a famous saying that "deadlines are the greatest motivator."

Selection factors. Let's imagine that a life cycle is like a field, and we need to move from our current position to the other side of the field. The field is littered with pits of all sizes—some are barely noticeable, while others are bottomless. We must choose whether to step over the pits or go around them. Going around takes more time, and if a pit is too long for us to jump over, we might trip or fall into it. The choice of whether to step over or go around the pits is entirely up to us, as illustrated in Figure 9.

Cognitive factors. At the initial stage, intelligent individuals are influenced by cognitive factors and remain confined to a

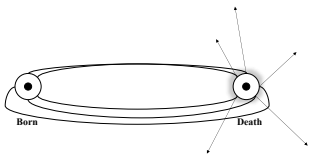


Fig. 8. Example of born to death condition 2.

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Fig. 9. Example of selection factor.

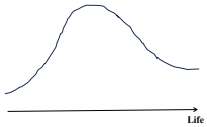


Fig. 11. Example of heart factor.

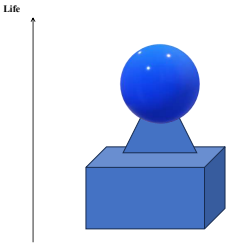


Fig. 10. Example of cognitive factor.

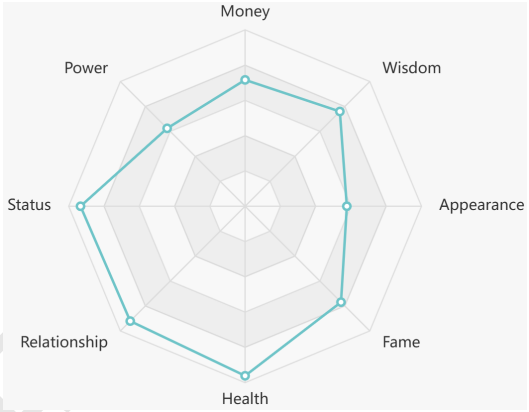


Fig. 12. Example of the personal value dimension.

particular state. In the later stages, as cognition changes, their state begins to shift continuously, as illustrated in Figure 10.

Flow factors. Every individual possesses its own independent system, maintaining unique inputs and outputs; for example, plants take in water and inorganic substances and produce organic matter; animals consume food and release heat and food waste, thereby maintaining an increase in entropy; machines process programmes and produce ordered behaviour. The total amount of matter and energy remains constant whilst flowing through time and space.

Miscellaneous. Certain environmental laws and principles illustrate the patterns by which groups composed of individuals form, such as the Boxed Pig Game (5) and the phenomenon where 58% effort yields the same results as no effort at all.

Heart factors. Assuming that within the lifespan of each individual, changes occur within the mind as experiences accumulate. We assume that each individual is in good condition at the beginning of life, and gradually experiences losses as they grow older. For instance, a teacher may lack teaching experience in the early stage of their career, but they possess a strong passion for teaching and a willingness to assist students in learning. As one's teaching career progresses, although they gain more teaching experience, their patience with students may diminish as illustrated in Figure 11. Therefore, longer working experience does not necessarily mean greater effectiveness. (6) investigated the relationship between a doctor's working experience and medical quality, while (7) explored the relationship between deliberate practice and performance.

Duo-individual system. Then, we expand our physicality and intelligence to more dimensions, a personal value dimension as shown in the Figure 12.

"Coupling" and "dating" both pertain to activities involving two people.

Interaction factors. Two individuals approach each other due to needs or attraction, but drift apart after a period of time. Poincaré proved that, given enough time, the two individuals will meet again. The position of each individual is like a tooth on a gear. When two gears intersect, due to contact or active behavior, they move onto the teeth of the other gear, or onto another gear on the same central axis, and then come into contact with and move along with other gears. This encounter is like returning to the original gear after countless steps, as shown in Figure 13.

Three individual system. The renowned science fiction novel "The three body problem" (8) mentions that a system consisting of three celestial bodies orbiting each other cannot be precisely solved due to its chaotic nature. There is a story in China about three people running out of water to drink.

Similarly, in tennis, the player who hits the ball, the player who retrieves the ball, and the player who serves the ball constitute three separate systems.



Fig. 13. Example of the tooth on a gear.

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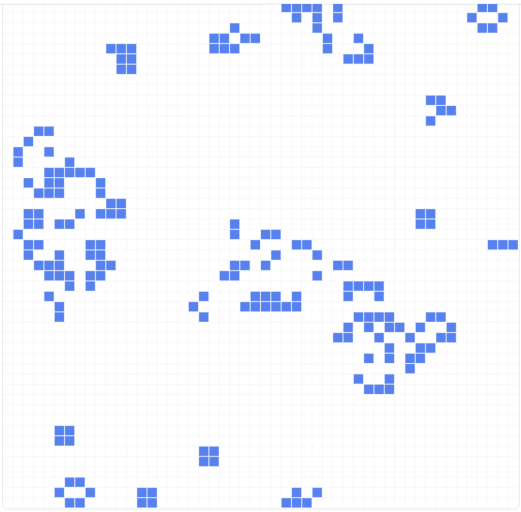


Fig. 14. An example of three individuals existing simultaneously in a simulation of the life game.

During the simulation of the digital life game, a stable phenomenon was discovered, namely that three individuals relied simultaneously on something existing in a certain space within a certain period of time. As shown in the Figure 14.

The producers, decomposers and consumers in the biological world belong to this system. Cloning falls under the category of three-body behavior.

Four individual system. The situation of the four individual systems is the same as that of the two individual system.

Swarm system. Mathematician John Horton Conway designed the Game of Life (9). During its operation, he discovered stable states consisting of 4, 5, and 6 entities [*]. Simulated observations revealed a phenomenon where three individuals coexisted for a certain period of time. The game "battle of balls" simulates this system.

We expanded the scenario to a multi-person situation and conducted simulations of this behavior. We use ELO to simulate the interaction.

This is a cyclic model consisting of three entities, as shown in Figure 15 (a). This model can be extended to include multiple entities. When a certain step of this cycle is disconnected, inputs and outputs can be introduced, forming a system with inputs and outputs. The following are two model structures with inputs and outputs, as shown in Figure 15 (b) and (c).

In addition, several possible structures need to be explored. We have listed four other network structures: the producer-decomposer-consumer network shown in Figure 16, the user-product unidirectional network shown in Figure 17, the human-machine bidirectional network shown in Figure 18, and the creator-decision-maker structure shown in Figure 19.

When the strong group approaches the intelligent group, their value dimensions may merge and converge towards the middle. But at this point, their value may not be able to obtain energy independently. Before absorbing the energy, it might be stolen by other individuals, and at this point, the game begins. Therefore, when the group expands to a sufficiently large size and reaches a level below the threshold for independent energy acquisition, the group will continue this process.

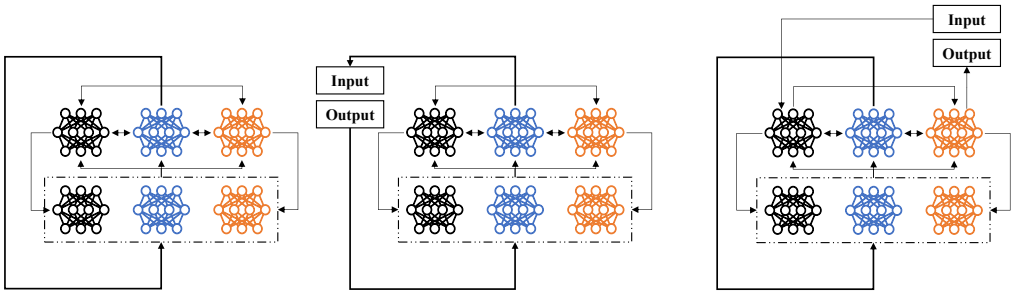
Due to the abundance of dimensions and the fact that they can be interchanged among each other, we consider this system to be cyclic.

[*] https://lzj.ac.cn/zh-TW/tools/simulator/game-of-life

Prediction. **ACKNOWLEDGMENTS.** Please include your acknowledgments here, set in a single paragraph. Please do not include any acknowledgments in the Supporting Information, or anywhere else in the manuscript.

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(a) three-individual cyclic model

(b) three-individual cyclic model with input and output scheme A

(c) three-individual cyclic model with input and output schemes B

Fig. 15. An flowchart of three-individual cyclic model. Thicker lines indicate a higher priority.

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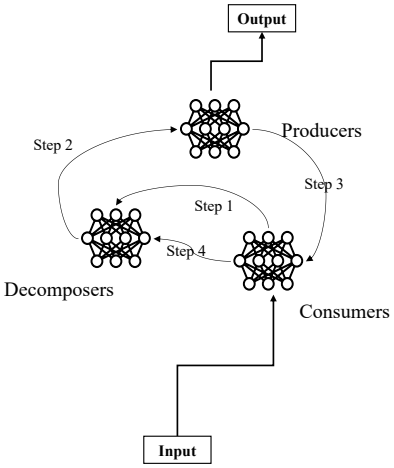


Fig. 16. An flowchart of three-individual cyclic model. Thicker lines indicate a higher priority.

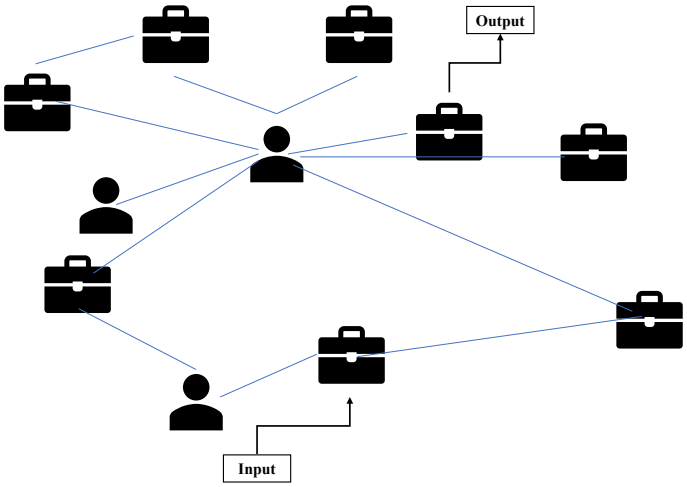


Fig. 17. An flowchart of three-individual cyclic model. Thicker lines indicate a higher priority.

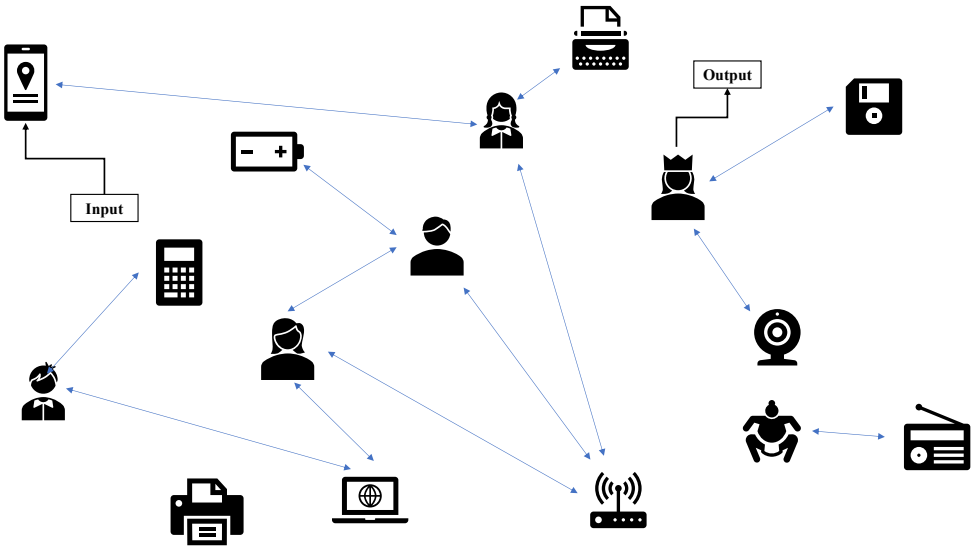


Fig. 18. An flowchart of three-individual cyclic model. Thicker lines indicate a higher priority.

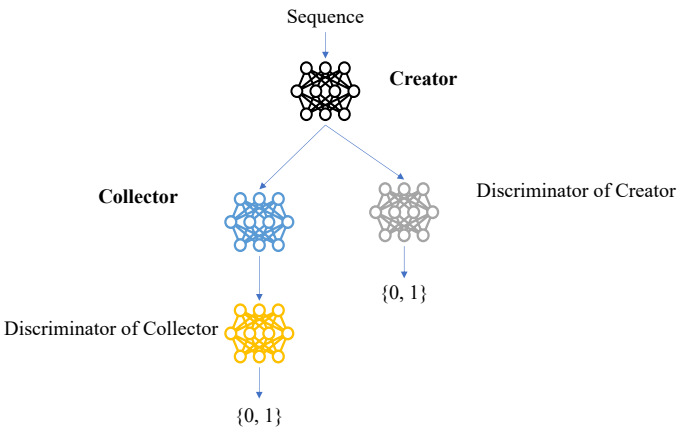


Fig. 19. An flowchart of three-individual cyclic model. Thicker lines indicate a higher priority.