# Love is a complicated game.

## Summary:

Online dating is becoming a more popular way for people to meet.

The dating market can be viewed as a two-sided market where individuals act as "agents" seeking to optimise their outcome, which in this case could be finding the "best" partner.

Game theory offers a framework to analyse this scenario and explore the potential market dynamics and strategic behaviour of individuals.

## Key ideas:

* Understand the dynamics of modern online dating markets.
* Determining optimal strategies for successful dating.

## The game:

**Players:** Individuals (users) seeking romantic partners on the platform.

**Strategies:**

* **Profile creation and presentation:** Choosing how to represent themselves through photos, bio, and other profile information.
* **Communication styles and interaction:** Deciding how to initiate contact, engage in conversation, and present themselves during interaction.
* **Matching preferences:** Setting criteria for potential partners based on various factors like interests, values, or desired characteristics.
* **Decision-making:** Choosing when to swipe right/left, initiate contact, accept/decline dates, or end communication.

**Information:**

* **Incomplete:** Each player has limited information about other players, primarily based on their profiles and limited interactions.
* **Imperfect communication:** Communication can be misconstrued or influenced by individual strategies and biases.

**Payoffs:**

* **Subjective and individual:** Each player seeks different outcomes, such as finding a compatible partner, experiencing positive interactions, or forming a long-term relationship.
* **Non-monetary:** Payoffs are measured in terms of satisfaction, emotional fulfilment, or personal growth rather than monetary gains.

**Dynamics:**

* **Simultaneous play:** Players make decisions simultaneously, unsure of others' actions.
* **Iterative interactions:** Players can engage in multiple interactions with different individuals over time.
* **Evolving preferences:** Individual preferences and strategies can adapt based on experiences and learning.

**Possible "winning" strategies:**

* **Finding a compatible partner:** Achieving a personal sense of satisfaction and fulfilment in the relationship.
* **Building meaningful connections:** Engaging in positive and enriching interactions with others, regardless of final outcome.
* **Learning and adapting:** Effectively utilising the platform and adjusting strategies to improve future experiences.

**Challenges and limitations:**

* **Defining objective "payoffs":** Measuring individual satisfaction and relationship success is complex and subjective.
* **Accounting for diverse motivations:** Individuals enter the game with various goals and expectations, making it difficult to generalise strategies.
* **Ignoring emotional complexities:** Game theory simplifies human behaviour and doesn't capture the emotional and social nuances of dating.

## Research Questions:

**1. identify communication styles:**

* **Question:** Can multi-agent reinforcement learning (MARL) be used to identify communication styles that contribute to strong connections in online dating platforms?
* **Problem:** Traditional dating platform algorithms rely primarily on user profiles and basic compatibility metrics, potentially overlooking the impact of communication styles on match success. This research aims to explore if MARL can identify communication styles that lead to stronger connections, potentially improving user experience and matching effectiveness.

**2. Can MARL perform better than traditional methods ?:**

* **Question:** How can MARL be used to model and understand the complex dynamics of user interactions in online dating compared to traditional supervised learning approaches?
* **Problem:** Dating platforms operate in a dynamic environment with evolving user preferences and complex interaction patterns. Supervised learning models may struggle to capture these complexities. This research explores the potential of MARL to model and understand these dynamics, potentially offering valuable insights into user behaviour and facilitating platform improvements.

**3. Matching Preferences and Signalling:**

* **Question:** How do individuals **signal their preferences and qualities** in the dating market, and how do these signals influence the matching process? (e.g., profile information, communication styles, displayed interests)
* **Problem:** Individuals may strategically present themselves to attract more desirable partners. This research could explore how different signalling strategies affect matching outcomes and the overall efficiency of the market.

**4. Search Strategies and the "Optimal Stopping Problem":**

**Preface :** optimal stopping theory is often quoted as mathematically the optimal way to select a partner but its built on strong and restrictive underlying assumptions.

* **Question:** What search strategies do individuals adopt in the dating market, and how long should they continue searching before committing to a partner? (e.g., selective vs. broad approach, balancing exploration vs. commitment)
* **Problem:** Individuals face a trade-off between searching for a potentially better match and settling for a current option. This research could explore various search strategies and the factors influencing the "optimal stopping point" when deciding to commit to a relationship.

**5. Competition and Strategic Interaction:**

* **Question:** How does the **competition for desirable partners** affect individual behaviour and the overall market dynamics? (e.g., "league tables", strategic manipulation of profiles, competitive interactions)
* **Problem:** Individuals may adjust their behaviour based on the perceived competition and the actions of others. This research could analyse how competition shapes market dynamics and the potential emergence of undesirable outcomes like deception or negative social comparison.

**6. Evolution of Preferences and Matching Outcomes:**

* **Question:** How do individual preferences and expectations evolve within the dating market over time? (e.g., learning from past experiences, adjusting standards based on observed outcomes)
* **Problem:** Individuals' preferences and expectations may not be fixed but be influenced by the market dynamics and their own experiences. This research could explore how individual learning and adaptation shape the long-term evolution of the dating market and the resulting matching outcomes.

## Why MARL:

1. **Dynamic and Complex Interactions:** The dating market is a dynamic environment where user preferences and behaviours constantly evolve. MARL can handle multi-agent interactions where users learn and adapt over time, offering a more flexible approach compared to static models in supervised learning.

2. **Long-Term Relationships**: Dating applications are ultimately interested in facilitating successful long-term relationships, not just initial matches. MARL allows agents to learn through the entire interaction process, considering compatibility beyond initial attraction, which may be better captured through continuous interaction and learning.

3. **Exploring Diverse Strategies:** MARL enables agents to explore and experiment with different communication styles and interaction strategies, potentially discovering unforeseen patterns or connections not explicitly labelled in supervised learning data.

4. **Explainability and Transparency:** While traditional supervised learning models can be effective, they often lack transparency in their decision-making process. MARL allows for some level of explainability, enabling you to understand and analyse the communication styles and strategies the agents learn to be successful, potentially providing valuable insights into user behaviour.

## limitations of using MARL for this purpose:

* **Data Scarcity and Complexity:** Obtaining and ethically utilising real-world data reflecting complex human interactions poses challenges. Additionally, designing meaningful reward structures to define "successful matches" can be complex.
* **Computational Cost:** Training and running MARL algorithms can be computationally expensive compared to simpler supervised learning models.

Overall, while supervised learning might seem more straightforward initially, MARL offers a potentially more flexible and insightful approach to explore the dynamics of online dating beyond just initial match predictions.

## Online Dating in a MARL framework:

**State:**

* **Individual state:** Represents a player's profile, interaction history, and current preferences. This state would evolve over time as they interact with others, updating their perceived attractiveness or modifying their search strategy.
* **Market-level state:** This could include the distribution of player profiles, prevailing communication trends, or the overall competitive dynamics within the platform.

**Actions:**

* **Profile updates:** Modifying photos, descriptions, changing self-presentation
* **Search actions:** Deciding who to browse, view, or message
* **Communication actions:** Choosing different communication styles (e.g., direct, flirtatious, open-ended questions), deciding how much to reveal, etc.
* **Match decisions:** Accepting or declining connections, deciding to pursue further interaction, or ghosting.

**Transition Probabilities:**

* Transition probabilities model the likelihood of moving from one state to another based on actions. It gets more complex here as you'd ideally need to consider:
  + **Other players' actions:** Responses from the people a player interacts with are outside their direct control (probabilistic transition based on their chosen actions).
  + **Platform mechanics:** Certain actions might have a higher probability of being noticed depending on the platform's algorithms.

**Rewards:**

Defining rewards is crucial, but also tricky as it depends on your research question:

* **Short-term rewards:** Positive signals like reciprocated interest, engaging conversations, or getting a date.
* **Long-term rewards:** The ultimate success metric such as forming a fulfilling relationship. This is harder to model directly.
* **Negative rewards:** Rejections, negative experiences, time and effort wasted.

**Framework Considerations:**

* **Complexity:** A full MARL framework modelling the entire dating market would be incredibly complex with a vast state-action space. You'll likely need to simplify the problem or isolate specific aspects.
* **Data:** Obtaining relevant data for a full MARL simulation would be ethically challenging, likely requiring synthetic data generation or highly abstracted scenarios.
* **Cooperative vs. Competitive:** You could model the market as purely competitive (everyone optimising for their own outcomes) or introduce elements of cooperation where aligning strategies could be beneficial.