When to drop an important piece of information? Studying the effect of timing on information cascades in real-time social networks

Wenning Deng (wdeng2@caltech.edu)
Department of Humanities and Social Sciences
Pasadena, CA, USA

Antonio Rangel (rangel@hss.caltech.edu)
Department of Humanities and Social Sciences
Pasadena, CA, USA

Abstract

Most decisions are informed by personal and social information. Sequential sampling models have been applied in these situations to examine how individuals integrate personal and social information in the choice processes. We created a new paradigm involving information cascades, embedding participants in a hidden social network where they made decisions in real-time and could influence one another. We showed that drift-diffusion models can describe both the dynamics of the individual decision processes and the information cascades in the group. Furthermore, we perturbed the network with a shock and analyzed how the timing of a critical information release modulated its impact on information cascades.

Keywords: social decision making; sequential integration models; social networks

Introduction

Most decisions have to be made with imperfect and noisy information. Examples include whether or not to buy insurance or what stocks to invest in. We often use a combination of personal and social information to inform these decisions. Personal information reflects our individual assessment of the situation, based on the information that we have encountered. Social information comes from observing the choices that others make in the same situation. Optimal decision-making requires balancing between these two sources of noisy and incomplete information. However, not all social information is equally informative. Consider the betting market as an example: if someone changes their bet at the last minute, it may signal access to inside information, making their bet more predictive of the match outcome. As a result, agents may process social information differently depending on when it is received, and the timing of critical information release can have varying impacts on group-level informational cascades (Bikhchandani et al., 1998). This study is designed to characterize the computational basis of this type of decisions at the individual level, as well as the social dynamics that they generate.

Drift Diffusion Models (Ratcliff & McKoon, 2008) have been wildly applied in 2-force-choice tasks to examine how individuals integrate noisy evidence to make decisions such as which food option they prefer and which stimulus is more rewarding. It has also been applied to social decision-making (Tump et al., 2020). We tested DDMs in social decision-making where personal and dynamic social information were presented concurrently and found that simple DDMs can characterize not only individual's choices and response time but also group-level dynamics. Both data and our simulation suggest that the timing of the critical information release impacts the dynamics but not the final state of the network.

Methods

Task

We collected data from 90 subjects, divided into 6 groups of 15 people each. Subjects were embedded within a hidden circulant network with 4 neighbors each. Each subject played 150 trials of the game. In each trial, the computer randomly chose a weather (Sun or Rain), and subjects were asked to predict the weather. They were presented with two sources of information: 1) a unique personal signal, displayed as 100 random dots with two different colors (Orange or Blue), and 2) a live social signal, representing their local network and live updates of their neighbors' choices.

Each trial lasted for 12 seconds and the subjects were free to change their choices as many times as they wanted during the course of the trial. After each trial ended, subjects received feedback on the correct answer and their score in the trial. Subjects were incentivized to make an accurate choice as quickly as possible.

Unknown to the subjects, on every round we randomly picked 7 out of 15 people and gave them 46% dots in the correct color, and we gave the other 8 out of 15 people 54% dots in the correct color. The dot arrangement was different for every subject. Subjects were informed that they would be randomly assigned a location in the social network on every round, and thus their neighbors would be different across trials.

Importantly, we introduced a manipulation during the last 100 trials in which a piece of information was delivered to an individual partway through the trial. This information was 100 dots in the correct color and thus always indicated the true state of the world without uncertainty. In each trial of the experimental condition, the computer randomly selected a time point, either 2 or 5 seconds, at which to release the information. Just before that moment, the computer randomly selected an individual among those who had made an incorrect choice and released the information to them. Subjects were informed about the information release, but they were not told when and to whom the information would be dropped.

Computational Models

Decisions are modeled as a Relative Decision Value (RDV) which starts at an initial location b, with $b \neq 0$ indicating an initial bias. Every timestep the evidence favoring either option is accumulated at a certain rate d with some independent Gaussian noise e_t. A choice is made the first time the RDV crosses either the upper boundary α or the lower boundary $-\alpha$. Finally, a non-decision time τ accounts for motor delays unrelated to evidence accumulation. Specifically,

$$RDV_{t+1} = RDV_t + \delta_p E_p + \delta_s E_s(t) + e_t$$

where e_t is white Gaussian noise with mean 0 and variance σ^2. $E_p \subset \{-1, 1\}$ denotes if the personal signal favors Sun or Rain. $E_s(t) \subset [-4, 4]$ denotes the net neighbor evidence favoring Sun or Rain at time t. We fixed α = 1, b = 0, and τ = 0.9s. To capture change-of-minds after receiving the critical information, we set δ_p to 1 after the change in personal information.

Results

Behavioral

We found that people relied on both personal and social information to make decisions (fig. 2a). Subjects' decisions were more accurate when 1) their private information was indicative of the truth ($\beta_p = 1.12, ci = [0.93, 1.30]$) and 2) the decisions of their neighbors were more accurate ($\beta_s = 1.17, ci = [0.95, 1.40]$). On average, one nonconforming choice from a neighbor was enough for people to overrule their personal signal. The influence of each neighbor's choice on individual decisions was almost linear.

We found an effect of condition on choices. Specifically, group choice accuracy showed a steep initial increase after the critical information was dropped and then gradually plateaued (fig. 2c). Groups achieved a higher final accuracy in both t=2 and t=5 condition compared to the control condition. We did not find any differences in final choice accuracy between the t=2 and t=5 condition, suggesting that although information passing started at different times, the final accuracy was not affected by when the critical information was released.

Modeling

Our drift diffusion model can capture how people dynamically integrate social and personal information (fig. 2a, 2b). We found that people weighted their personal signal similarly to the choice from one neighbor ($\delta_p = 0.07, \delta_s = 0.07$). At group level, our model can predict the quality of the information cascade in a trial based on individual parameters and the initial condition only (fig. 2c).

Discussions

We designed a novel paradigm to study information cascades in social networks and found that while the timing of critical information release did not impact final group accuracy, it did influence the onset and duration of the information cascade. We developed a drift-diffusion model to capture how people dynamically integrate personal and social information. Our model can capture both individual- and group-level dynamics. This is an ongoing work and we are still in the process of analyzing data and testing hypotheses. The experiments and models make predictions about the information aggregation quality in different locations and time points in the network, which could serve as an entry point for improving decision-making in social networks.

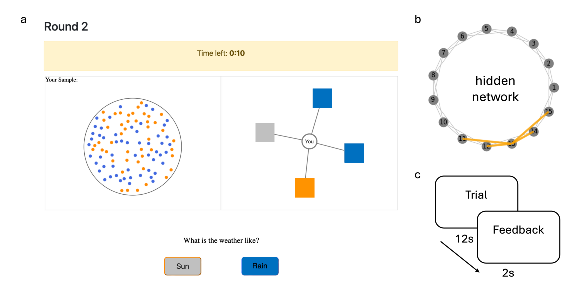

Figure 1: Task Paradigm.

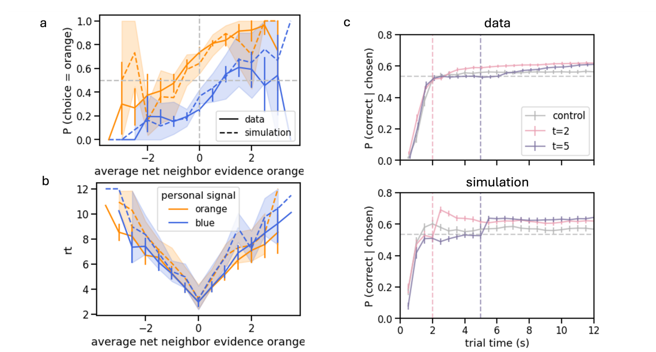

Figure 2: Result.

References

Bikhchandani, S., Hirshleifer, D., & Welch, I. (1998). Learning from the behavior of others: Conformity, fads, and informational cascades. *Journal of Economic Perspectives*, *12*(3), 151–170.

Ratcliff, R., & McKoon, G. (2008). The diffusion decision model: theory and data for two-choice decision tasks. *Neural computation*, *20*(4), 873-922.

Tump, A. N., Pleskac, T. J., & Kurvers, R. H. (2020). Wise or mad crowds? the cognitive mechanisms underlying information cascades. *Science Advances*, *6*(29), eabb0266.