Successful Social Learners Can Choose the Better of Two Options: An Agent-Based Simulation

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Letters on Evolutionary Behavioral Science

Figure S1
Two gamma distributions used in this study.

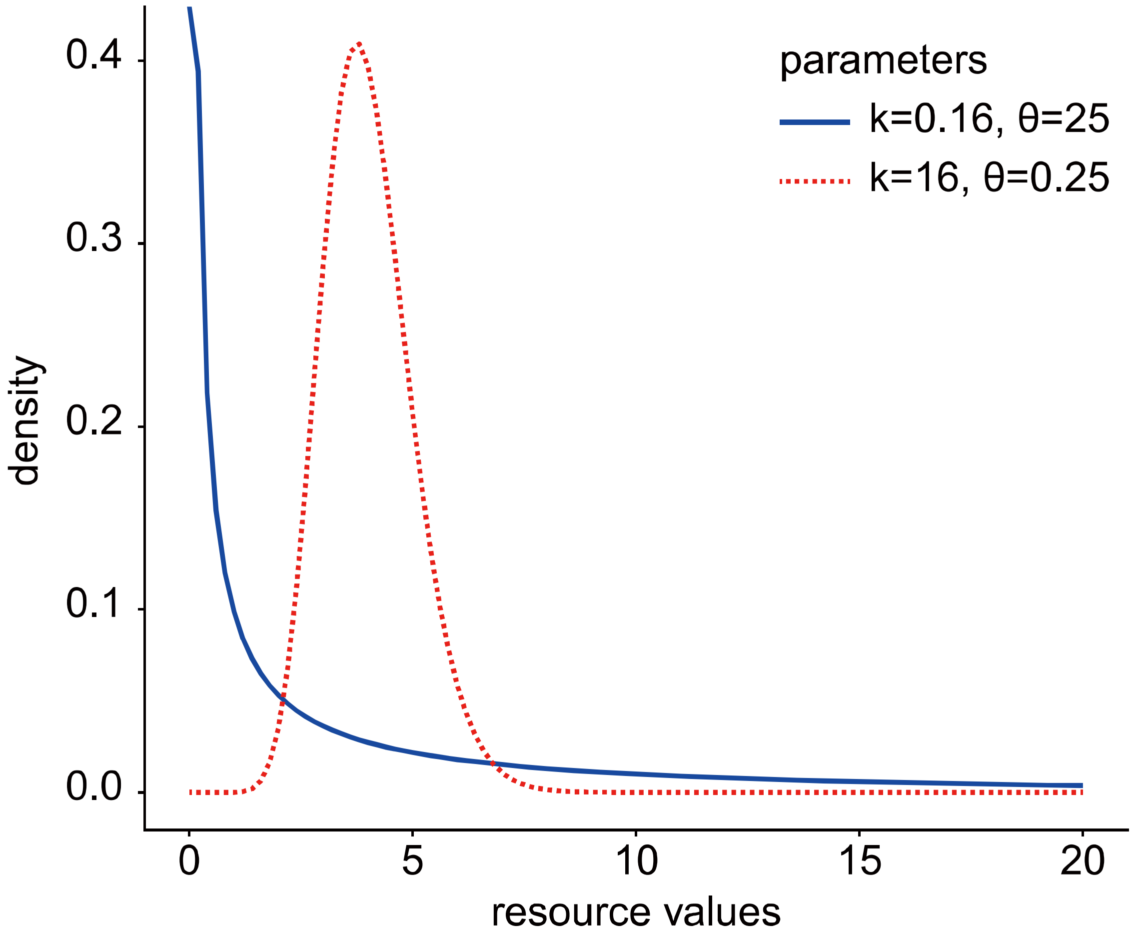


Figure S2

Mean rewards of social and individual learners under even resource distribution and no-competition as a function of information filtering and aggregation (Dotted lines indicate Smolla et al.'s (2005) results).

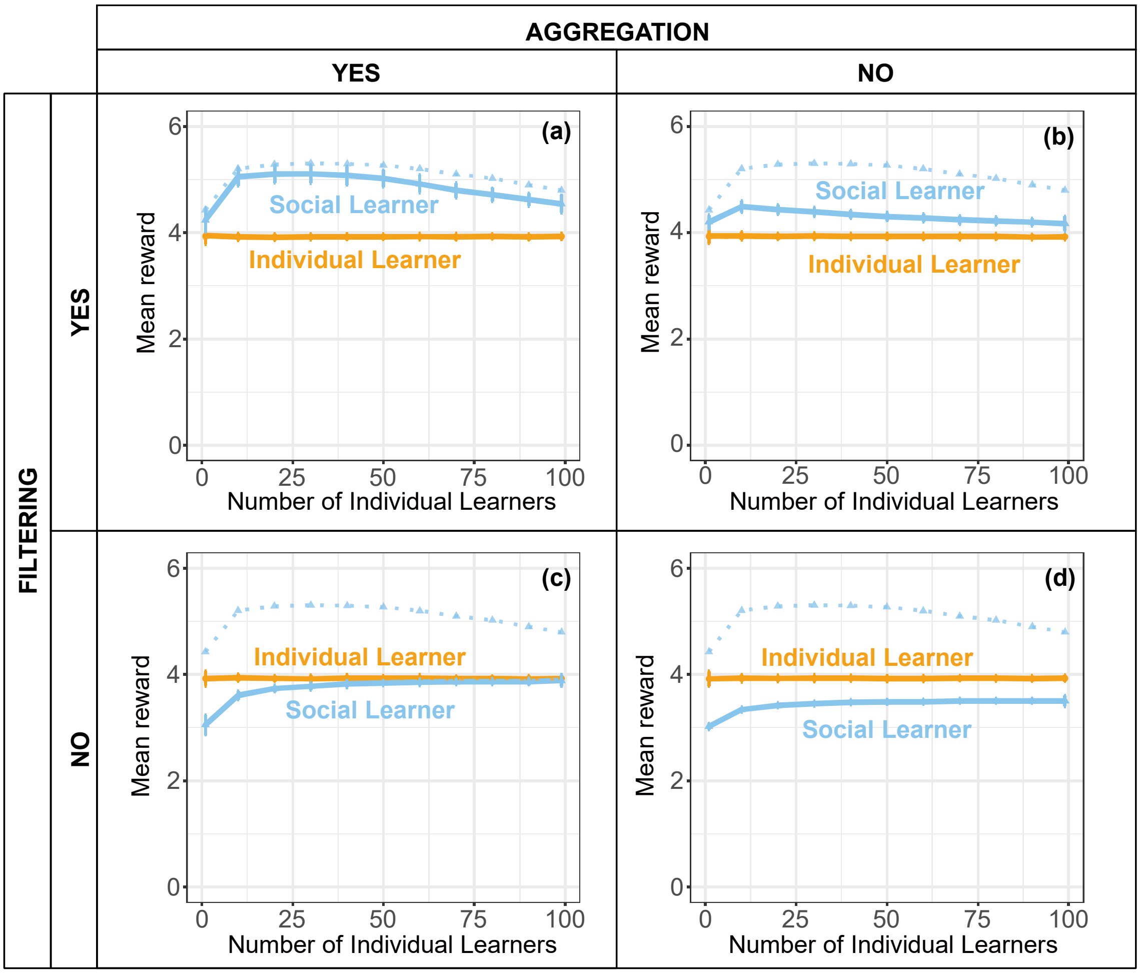
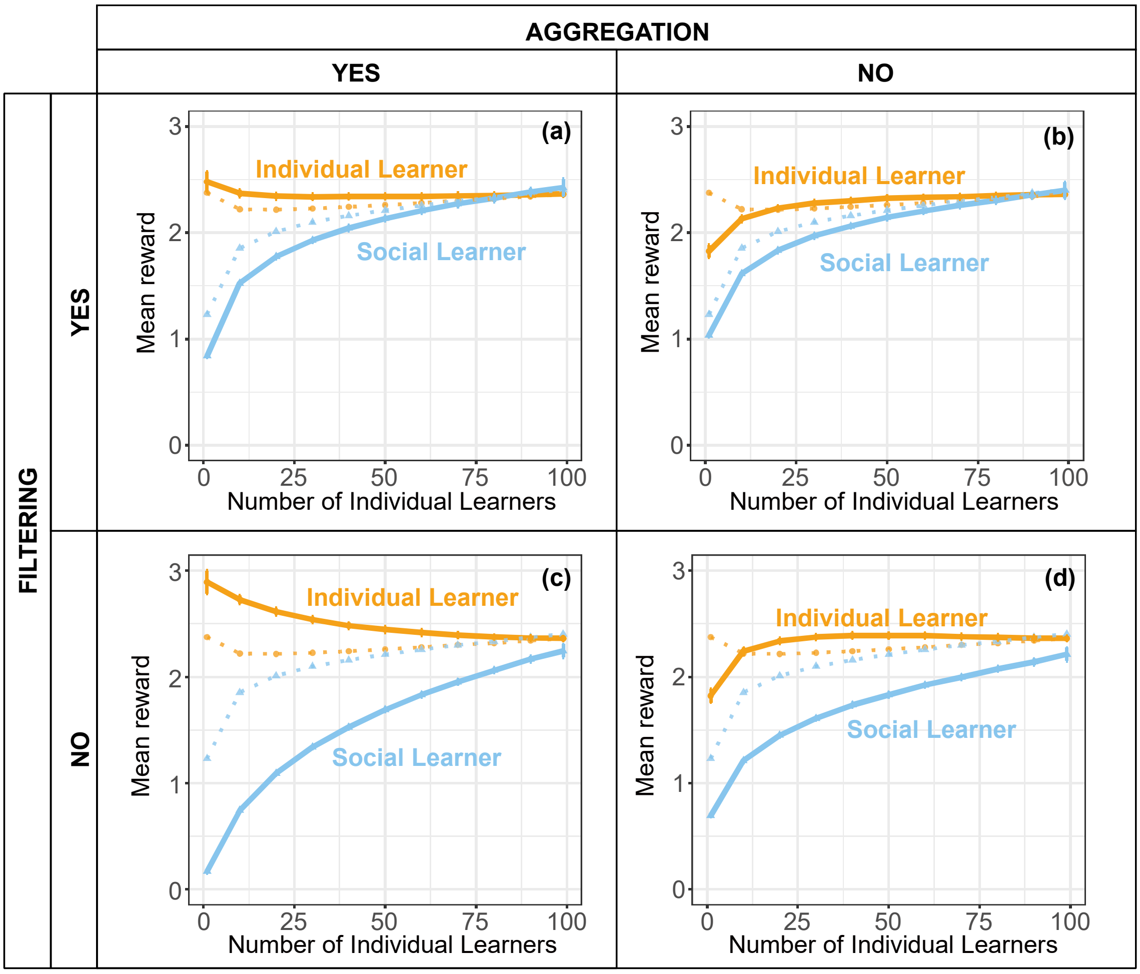


Figure S3

Mean rewards of social and individual learners under even resource distribution and competition as a function of information filtering and aggregation (Dotted lines indicate Smolla et al.'s (2005) results).



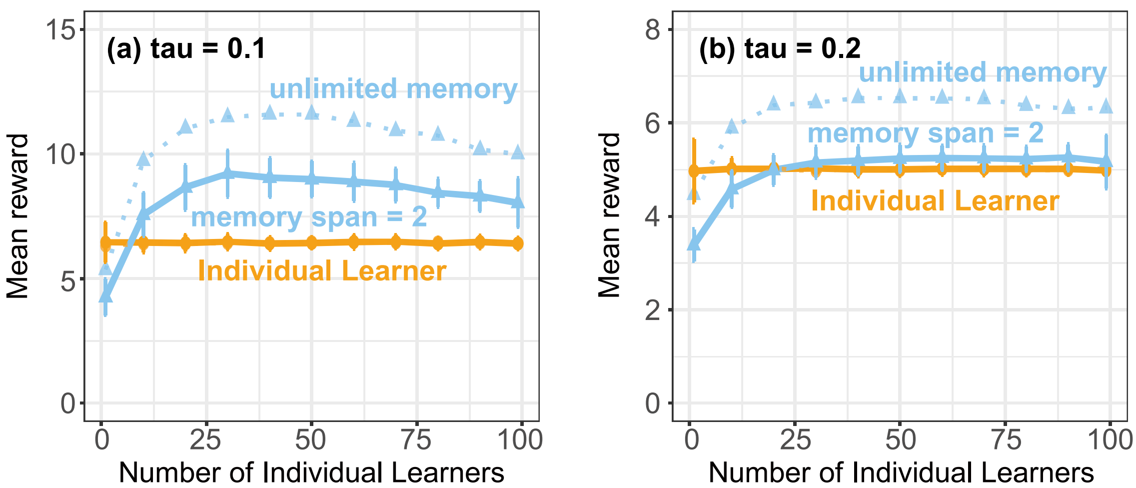
Robustness Check 1

The reviewer suggested that the effect of social learners' short memory span, which we introduced to test the core effect of information filtering (i.e., choosing the better option between the *two* most recently learned options), might hinge on the rate of environmental change, τ. Although we assumed that restricted memory is generally disadvantageous (e.g., Figure 2a), this assumption may hold only when the environmental change is slow. In our original simulations, τ = 0.01, which is equivalent to assuming that each patch's resource value remains constant for an average of 100 rounds. However, if the environment changes more rapidly, a short memory span might improve social learners' fitness by enabling them to quickly discard outdated information. To test this possibility, we reproduced Figure 2a using τ values of 0.1 and 0.2, which imply that each patch's resource value remains constant for an average of10 or 5 rounds, respectively. In particular, we conducted two sets of new simulations comparing social learners without memory restriction and social learners with memory restriction under these two higher rats environmental change (τ = 0.1 and 0.2).

The results are shown in Figure S4. Although two prominent difference from Figure 2a were observed (i.e., social leaners can no longer outcompete individual learners when individual learners are rare; and payoffs for both individual and social learners are lower under higher rates of environmental change—note that the vertical axis spans 0–40 in Figure 2a, compared to 0–15 in Figures S4a and 0–8 in Figures S4b), social learners with memory restriction (solid blue line) still did not outperform social learners without memory restriction (dotted blue line).

Figure S4

Replication of the simulation reported in Figure 2a under higher environmental change rates: (a) τ = 0.1. (b) τ = 0.2.

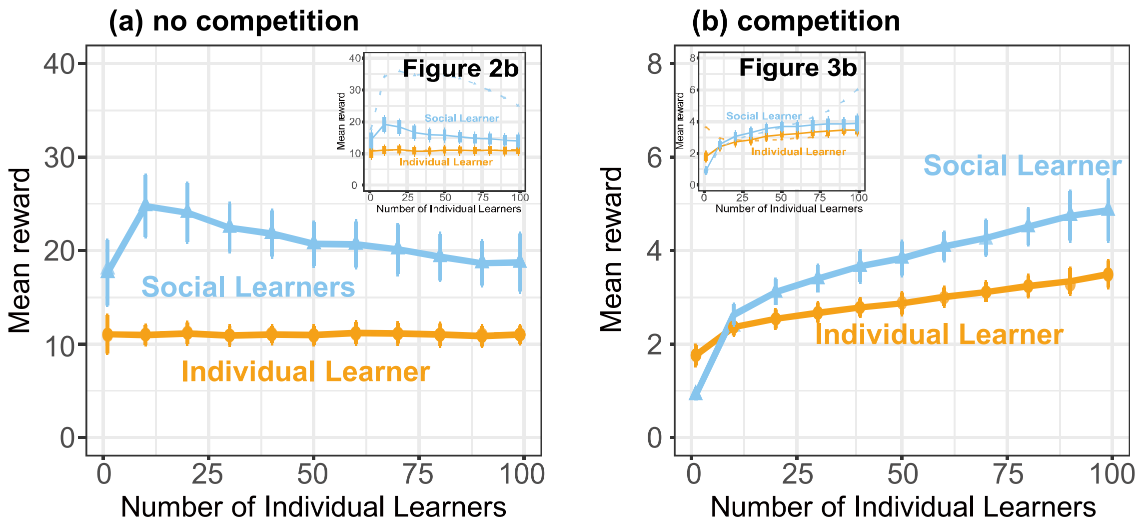


Robustness Check 2

The reviewer suggested that the difference in memory capacity between individual learners (unrestricted) and social learners (restricted) makes the comparison difficult. Across the eight panels depicted in Figure 2 and 3, this issue is specifically relevant to Figures 2b and 3b. For Figures 2a and 3a, the original simulation by Smolla et al. (2015) compared individual and social learners without memory restriction, which is reported by the dotted lines in these two figures. As for Figures 2c, 2d, 3c, and 3d, the simulations required depriving social learners of any memory capacity altogether to investigate the effect of information filtering. Accordingly, we reproduced Figures 2b and 3b by endowing social learners with unrestricted memory capacity. The results are shown in Figure S5. Although unrestricted memory capacity slightly increased social learners' payoffs, the general pattern remained unchanged.

Figure S5

Replication of the simulation reported in Figures 2b and 3b replacing social learners with memory restriction with social learners without memory restriction. Under (a) no competition and (b) competition, each corresponding to Figures 2b and 3b, respectively. A small panel within each panel showing the results of Figures 2b and 3b.



Why Did the Fitness of Social Learners Exhibit an Inversed-U Shape in Figures 1a, 2a and 2b?

In Figures 1a, 2a, and 2b, the fitness of social learners initially increases alongside the frequency of individual learners, but beyond a certain threshold, it declines as the frequency individual learners increases further. As we discussed in the main text (see Discussion section), the frequency of individual learners introduces two opposing forces:

(1) Expanded Pool of Exploited Patches

An increase in the frequency of individual learners monotonically increases the total number of exploited patches (Figures S6a and S6c).

(2) Overloaded Filtering Efficiency

Too many options force social learners to move more slowly toward top-tier patches, as they evaluate a new patch only once every five rounds on average ($\beta = 0.2$). Consequently, social learners spend more time exploiting lower-ranked patches rather than top-tier patches (Figures S6b and S6d).

While this mechanism is particularly relevant to the present model, where social learners' memory capacity is restricted to two slots, it also applies to Smoall et al.'s (2015) original model. Because social learners move only to better patches and the rate of environmental change is low ($\tau = 0.01$), social learners switch back from their current patch to a previously remembered best patch only infrequently (as this occurs only when the payoff value of the current patch drops). Although unrestricted memory capacity confers a noticeable benefit on social learners, especially when the frequency of individual learners (and thus the pool of exploited patches) is large, the difference between two-slot memory capacity (blue line) and unrestricted memory capacity (green line) is relatively small in both Figures S6b and S6d, when compared with the large gap between those two versions of social learners and those lacking memory and information-filtering capacity (orange line). This pattern further confirms the conclusion of the present study: Information filtering, rather than memory capacity size, is of central importance for social learners to outperform individual learners.

Figure S6

Mean number of exploited patches and mean rank of patches exploited by social learners as a function of the frequency of individual learners (horizontal axis) and memory restriction (color). (a) Mean number of exploited patches in the information aggregation condition. (b) Mean rank of exploited patches by social learners in the information aggregation condition. (c) Mean number of exploited patches in the no-information aggregation condition. (d) Mean rank of exploited patches by social learners in the no-information aggregation condition.