have been given special attention (Fig.1): Stern-judging (SJ, also known as Kandori), which assigns a good reputation to a donor that helps a good recipient or refuses help to a bad one, assigning a bad reputation in the other cases; Simple-Standing (SS), similar to SJ, but more "benevolent" by assigning a good reputation to any donor that cooperates; Shunning (SH), similar to SJ but less "benevolent", by assigning a bad reputation to any donor that defects; and Image Score (IS, actually a 1st order norm) where all that matters is the action of the donor, who acquires a good reputation if playing C and a bad reputation if playing D [5]. In the space of 2nd-order norms that we consider, a duple p suffices to unambiguously define a strategy of an agent, by specifying the action directed at a G or B recipient. This leads to the following 4 strategies to be used by agents: unconditional Defection (AllD, $p = (D, D)$), unconditional Cooperation (AllC, $p = (C, C)$), Discriminator strategy (Disc, $p = (C, D)$), that is, cooperate with those in Good reputation, and defect otherwise), and paradoxical Discriminator strategy (pDisc, $p = (D, C)$, the opposite of Disc).

Unlike previous studies, we seek to investigate the evolutionary dynamics of these 4 strategies within a multiagent system, by means of a stochastic birth-death process, both analytically [9] and through large-scale computer simulations [8]. We fix a social norm and let the system evolve by allowing agents to adopt strategies through social learning (i.e., the observed strategies leading to higher payoffs are adopted with higher probability) or through random exploration of the strategy space. The following questions are posed: **1) What social norms lead to higher levels of cooperation? 2) What social norms are robust to the inclusion of explorative agents, i.e., agents that behave non-strategically by randomly exploring the strategy space? 3) What social norms are robust if agents are allowed to error, both in attributing/retrieving wrong reputations or failing to act as their strategy conveys?**

2. RESULTS

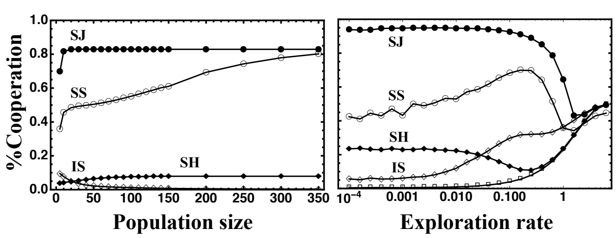

Figure 2: Left: The effect of population size on the emergent cooperation levels for each social norm; a single norm known as Stern-Judging (SJ) stands out for small population sizes. Right: Cooperation under Simple-standing (SS) and Image-score (IS) profits from high exploration rates.

Through analytical tools [9] and large-scale computational simulations [8], we show that population size strongly influences the merits of each social norm (Fig.2). While more than one social norm is able to promote high levels of cooperation in large populations (SJ and SS), in small populations only a single social norm proves to be efficient (SJ), a property that can be comprehended by assessing the corresponding collective dynamics of strategy adoption [9].

Additionally, we show that high exploration rates (i.e., allowing agents to explore the strategy space with high probability) particularly leverage cooperation in systems where the governing social norm is either SS or IS (Fig.2). Again, we provide a simulation toolkit that allows comprehending these results, by keeping a detailed track of the dynamics resulting from the process of strategy adoption by agents [8]. Future work shall emphasise the characteristics of agents that allow an effective adherence to social norms as well as how different social norms may compete with each other.

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