Supplemental Material
Culture and cooperation in a spatial public goods game

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1 Model implementation

Source code (C++ and Python with MPI [1]) for the model is available from `https://sites.google.com/site/alexdstivala/home/culture_cooperation`.

2 Different values of lattice dimension L

Figures S1, S2 and S3 show the fractions of cooperators, average number of players per public goods game, and number of cultural regions, respectively, for two (smaller) values of L different from $L = 100$ used in the main text. All other parameters are the same as those described the main text. The results are not qualitatively different, although the critical value of q may differ.

3 Different values of the marginal per capita return (MPCR)

Figures S4, S5 and S6 show the fractions of cooperators, average number of players per public goods game, and number of cultural regions, respectively, for four different values of the marginal per capita return (MPCR, or β as described in the main text), including MPCR $= 0.6$ as used in the main text (which is plotted with more values of q around the critical value). All other parameters are the same as those described the main text. The results are not qualitatively different.

4 Different values of Fermi update function uncertainty value K

Figures S7, S8 and S9 show the fractions of cooperators, average number of players per public goods game, and number of cultural regions, respectively, for three different values of the Fermi update function uncertainty parameter K, including $K = 0.1$ as used in the main text. The results are with four different values of the culture selection and perturbation noise rate $r = r'$, and two values of the lattice dimension L, including $L = 100$ as used in the main text. All other parameters are the same as those described the main text.

Figure S7 shows that the smaller value of K ($K = 10^{-6}$) makes no significant difference to the fraction of cooperators remaining for the parameters tested, compared to the value $K = 0.1$ used in the main text. However the larger value of K ($K = 10$) results in more cooperators remaining than for lower values of K, when q is large enough that cooperators remain at all.

Figures S8 and S9 show that there is no significant difference in the average numbers of players per public goods game, or the number of cultural regions, for the three different values of K tested.

References

[1] Lisandro Dalcín, Rodrigo Paz, Mario Storti, and Jorge D'Elía. MPI for python: Performance improvements and MPI-2 extensions. *J. Parallel Distr. Com.*, 68:655–662, 2008.

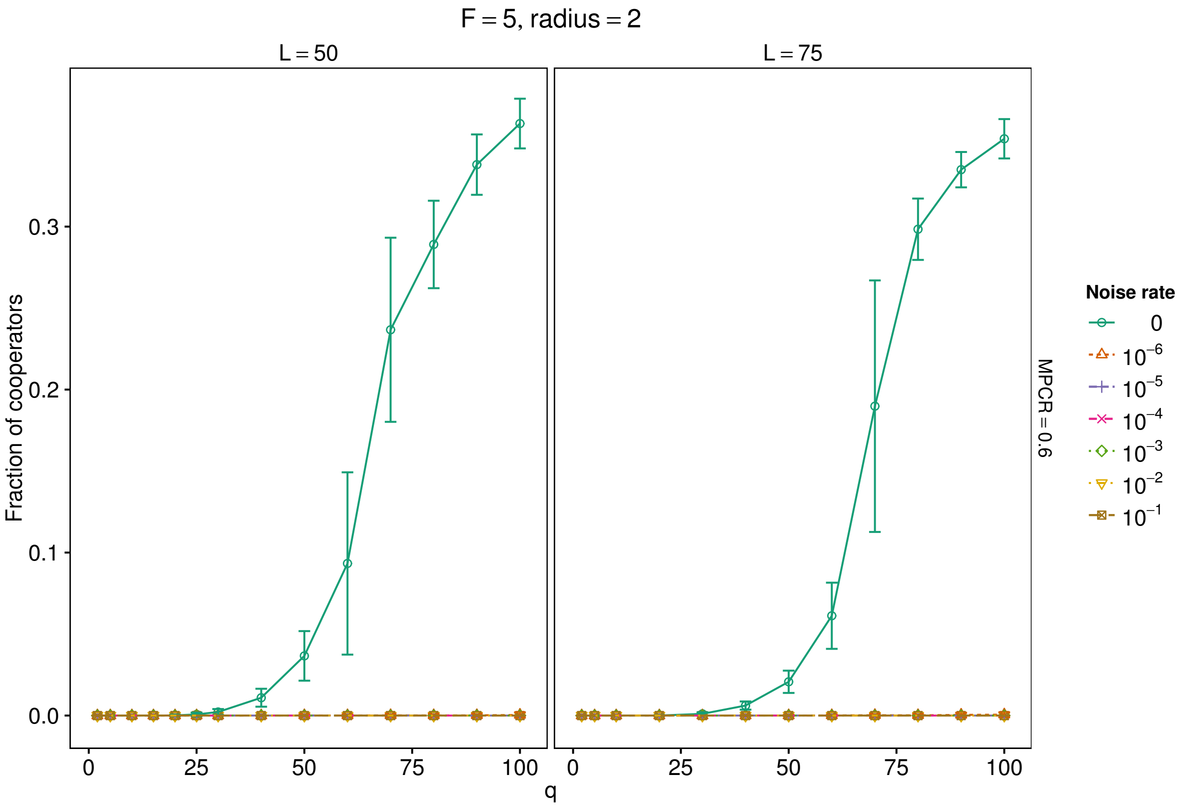

Figure S1: Fraction of agents which are (conditional) cooperators after 10^9 steps as a function of q for different noise rates, for two different values of the lattice dimension L. Lines are shown purely as an aid to the eye as q is an integer.

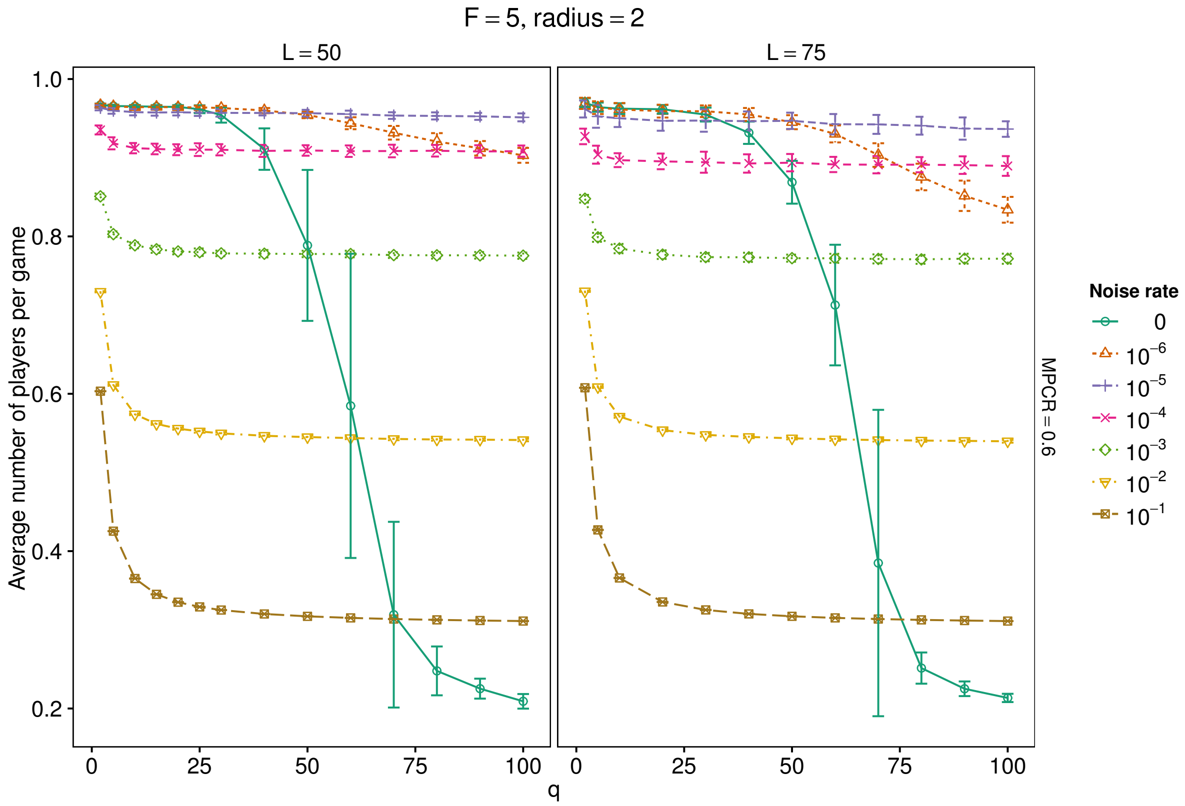

Figure S2: Average number of players per public goods game after 10^9 steps as a function of q after 10^9 steps as a function of q for different noise rates, for two different values of the lattice dimension L. The average number of players per game is normalized by division by the maximum possible number of players, which is the number of agents in the von Neumann neighborhood of the focal agent. Lines are shown purely as an aid to the eye as q is an integer.

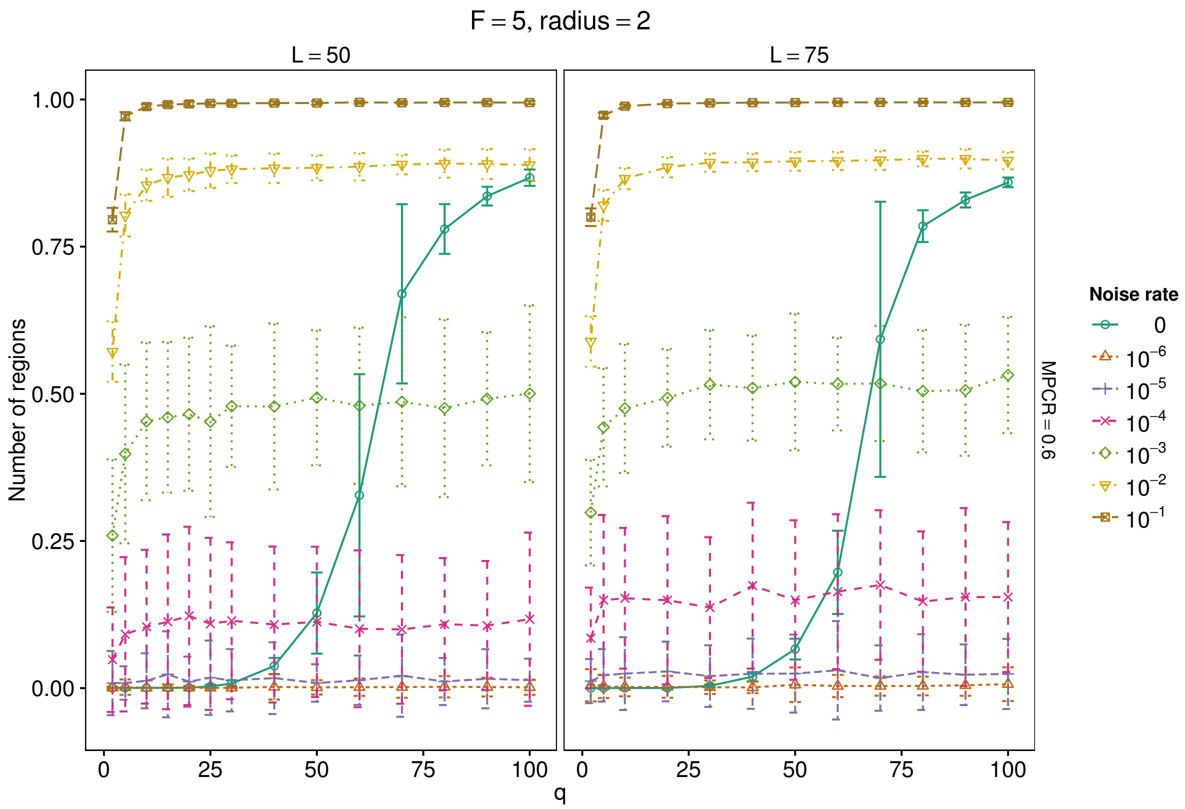

Figure S3: Number of cultural regions (normalized by division by number of lattice sites) after 10^9 steps as a function of q for different noise rates, for two different values of the lattice dimension L. Lines are shown purely as an aid to the eye as q is an integer.

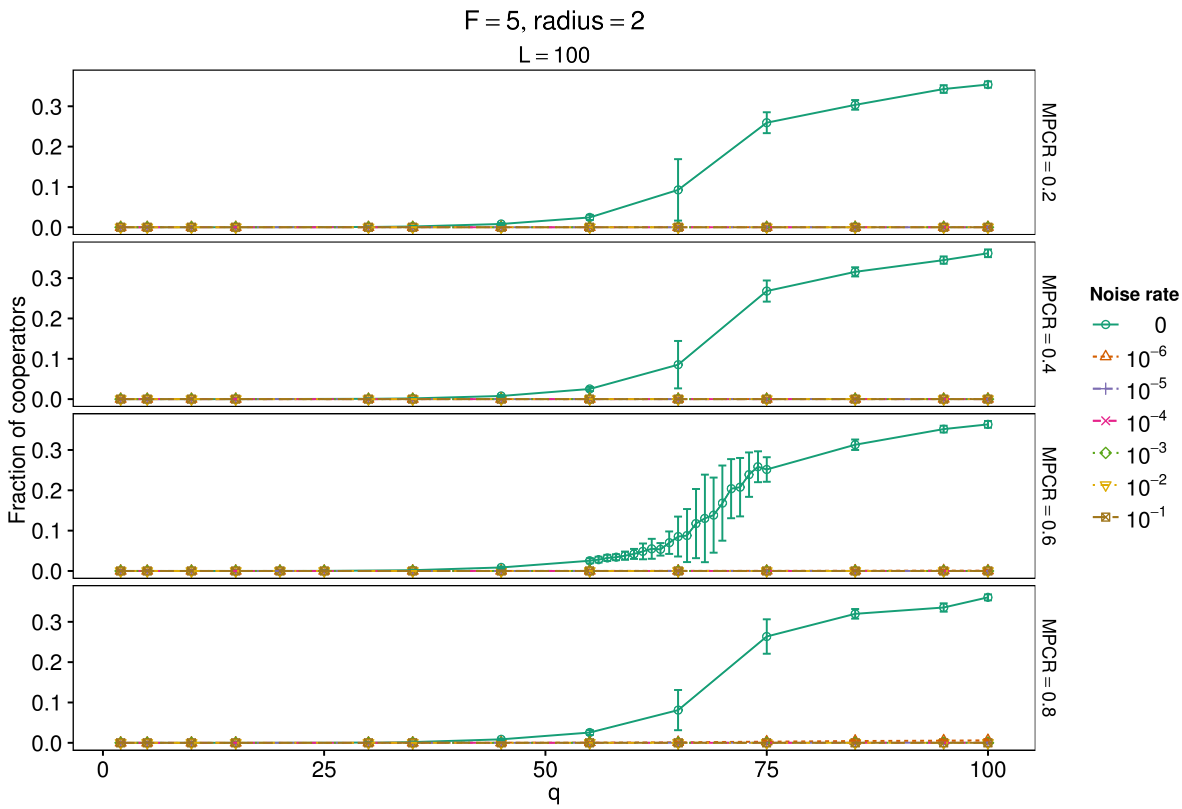

Figure S4: Fraction of agents which are (conditional) cooperators after 10^9 steps as a function of q for different noise rates, for four different values of the MPCR. Lines are shown purely as an aid to the eye as q is an integer.

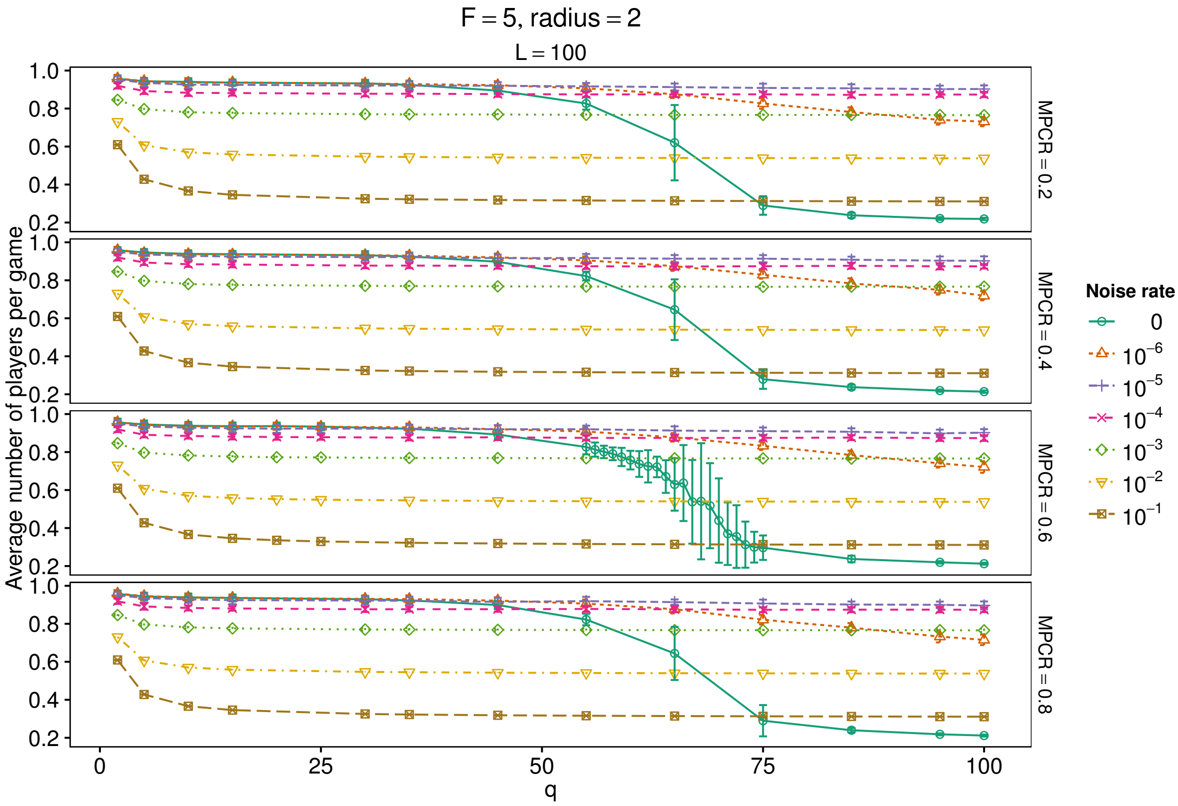

Figure S5: Average number of players per public goods game after 10^9 steps as a function of q after 10^9 steps as a function of q for different noise rates, for four different values of the MPCR. The average number of players per game is normalized by division by the maximum possible number of players, which is the number of agents in the von Neumann neighborhood of the focal agent. Lines are shown purely as an aid to the eye as q is an integer.

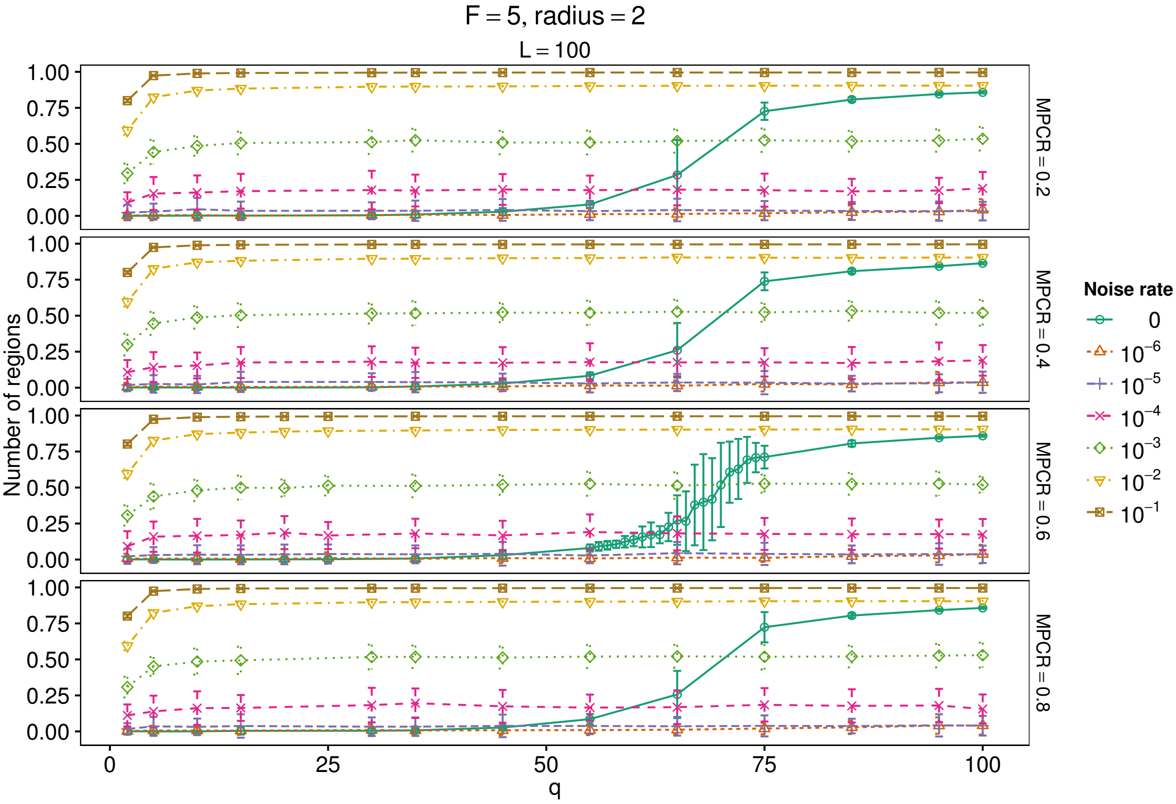

Figure S6: Number of cultural regions (normalized by division by number of lattice sites) after 10^9 steps as a function of q for different noise rates, for four different values of the MPCR. Lines are shown purely as an aid to the eye as q is an integer.

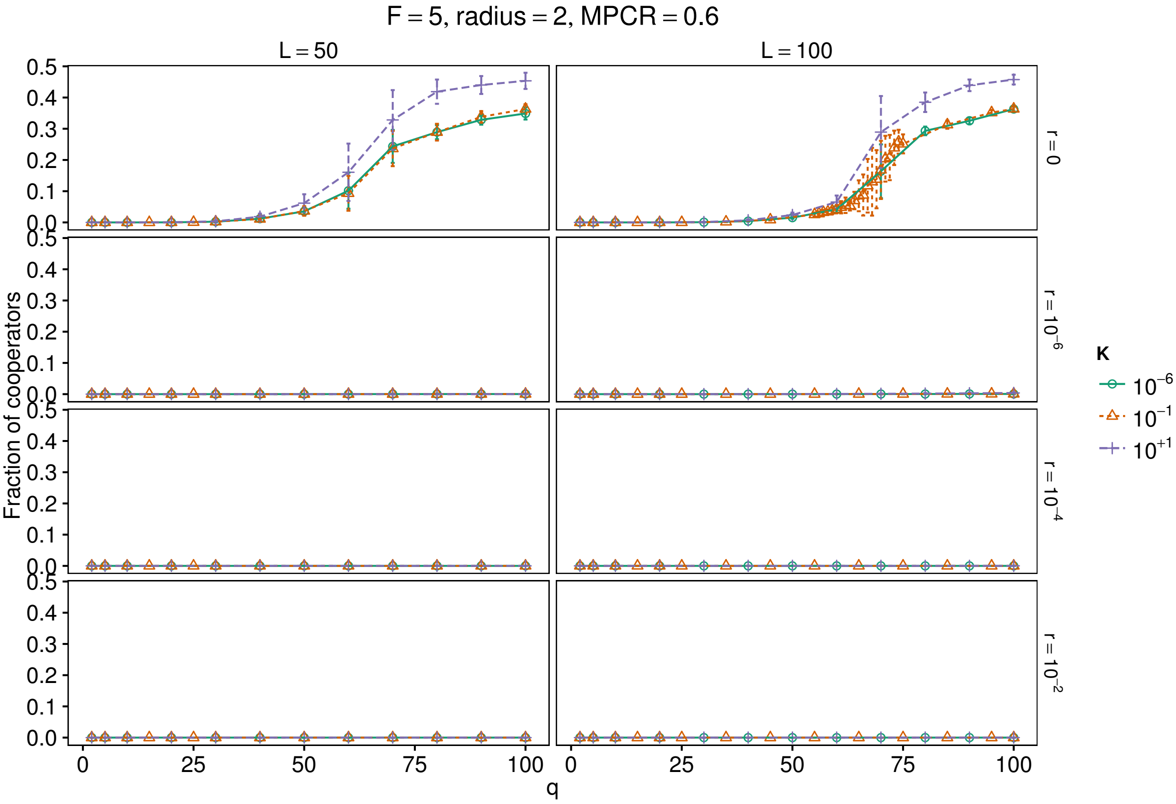

Figure S7: Fraction of agents which are (conditional) cooperators after 10^9 steps as a function of q for different noise rates, for three different values of the Fermi update function uncertainty parameter K. Lines are shown purely as an aid to the eye as q is an integer.

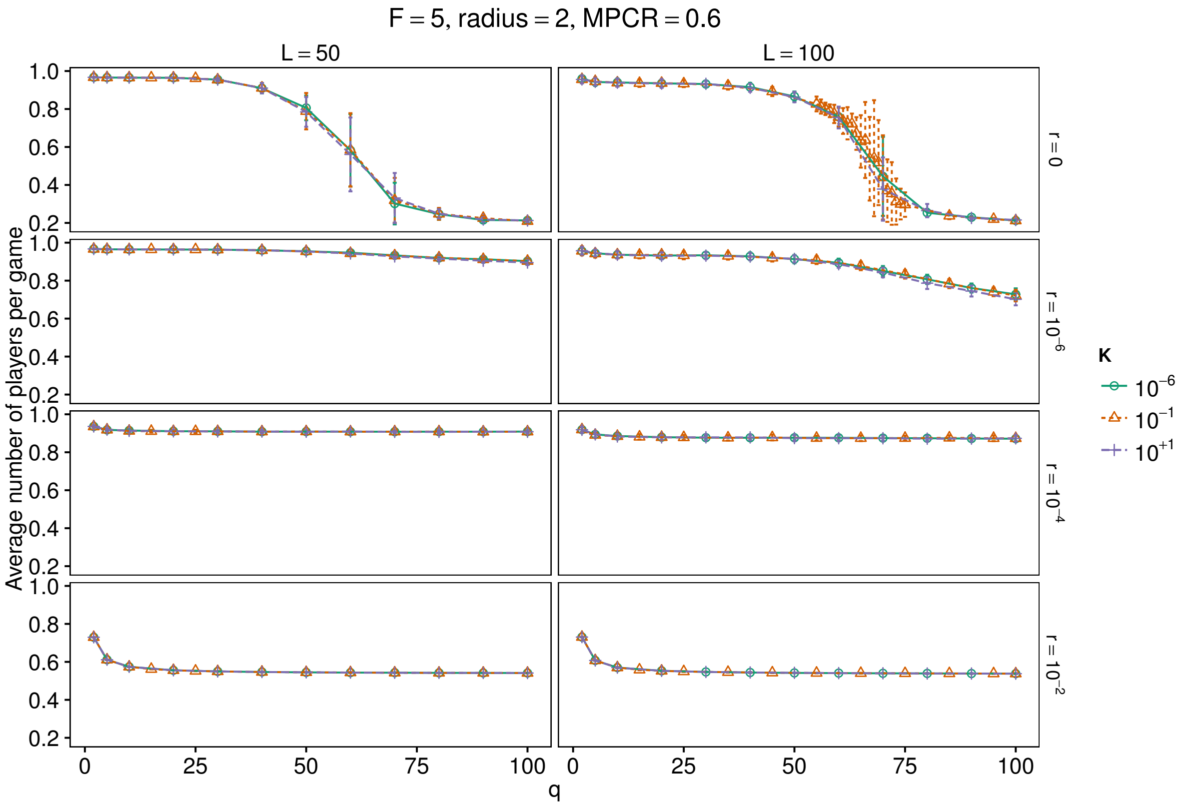

Figure S8: Average number of players per public goods game after 10^9 steps as a function of q after 10^9 steps as a function of q for different noise rates, for three different values of the Fermi update function uncertainty parameter K. The average number of players per game is normalized by division by the maximum possible number of players, which is the number of agents in the von Neumann neighborhood of the focal agent. Lines are shown purely as an aid to the eye as q is an integer.

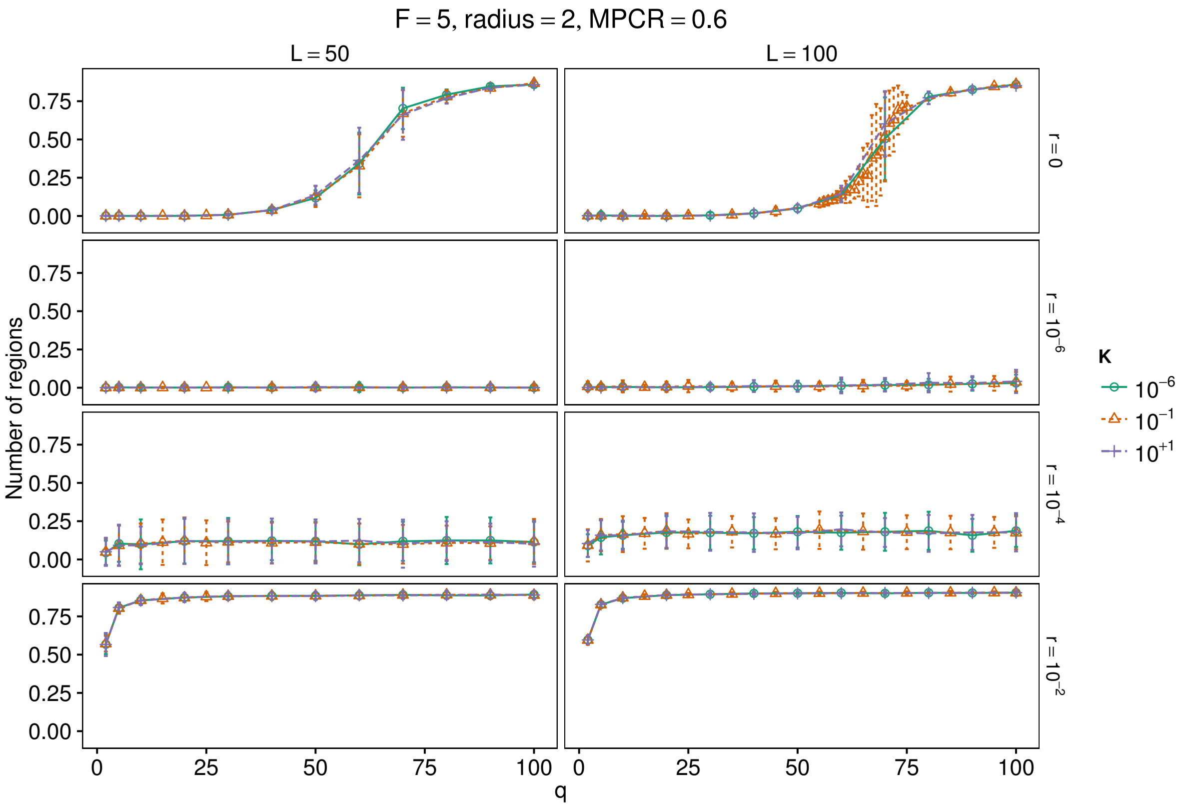

Figure S9: Number of cultural regions (normalized by division by number of lattice sites) after 10^9 steps as a function of q for different noise rates, for three different values of the Fermi update function uncertainty parameter K. Lines are shown purely as an aid to the eye as q is an integer.