Self-similarity of turning avalanches in schooling fish

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Groups of animals are observed to transmit information across them with propagating waves or avalanches of behaviour. These behavioral cascades often display scale-free signatures in their duration and size, ranging from activating a single individual to the whole group, signatures that are commonly related to critical phenomena from statistical physics. A particular example is given by turning avalanches, where large turns in the direction of motion of individuals are propagated [1]. Employing experimental data of schooling fish, we examine characteristics of spontaneous turning avalanches and their dependency with schools of different number of individuals. We report self-similar properties in the avalanche duration, size and inter-event time distributions, as well as in the avalanche shape [2].. We argue that turning avalanches are a result of collective decision-making processes to select a new direction to move. They start with the group having low speed and decreasing the coordination, but once a direction is chosen, speed increases and coordination is restored. We report relevant boundary effects given by wall interactions and by individuals at the border of the group. We conclude investigating spatial and temporal correlations using the concept of aftershocks from seismology. Contrary to earthquakes, turning avalanches display statistically significant clustered events only below a given time scale and follow an Omori law for aftershocks with a faster decay rate exponent than that observed in real earthquakes [2].

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[1] J. Múgica, J. Torrents, J. Cristín, A. Puy, M.C. Miguel and R. Pastor-Satorras, *Scale-free behavioral cascades and effective leadership in schooling fish*, Scientific Reports **12**, 10783 (2022).

[2] A. Puy, E. Gimeno, D. March, M.C. Miguel and R. Pastor-Satorras, *Self-similarity of turning avalanches in schooling fish*, Preprint available here: http://arxiv.org/abs/2309.16455