Title
Visual Interaction Networks and Leadership in Walking Crowds
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Collective motion in human crowds is a self-organized behavior that emerges from visual interactions between pedestrians. While the macroscopic patterns are generated by local interactions among neighbors, some individuals play the role of "leaders" who strongly influence the crowd. Can "leadership" be attributed to personal qualities, or does it emerge from spatial relations within a crowd? We describe a method to reconstruct the structure and dynamics of interaction networks in human crowds and quantify individual leadership. We used Time-Dependent Delayed Correlation (TDDC) and network theory to analyze motion-capture data on human "swarms" (N=10, 16, 20). Participants were instructed to walk about the tracking area while staying together as a group, yielding 15 min of continuously tracked data. TDDC allows us to infer the leadership relation for all pairs of pedestrians, based on the sign of the time delay. Interaction networks were reconstructed at 1s intervals, with the degree of influence represented by the %time in the lead. Network links were pruned using (i) influence, (ii) reaction time, (iii) field of view, or (iv) visual occlusion criteria. We introduce a new measure of the relative influence of every pedestrian, called *net leadership*. By representing interaction networks spatially, we disentangle the role of individual influence and spatial position on leadership emergence. Network structure reveals that, whereas individual differences in net leadership are small, leadership strongly depends on spatial position: there is a leadership gradient from the front to the back of the crowd. Moreover, network dynamics reveal that the individuals occupying leadership positions change over periods of seconds. The results demonstrate that visual interaction networks can be reliably reconstructed and used to analyze influence and leadership in a crowd. The method enables predictions of crowd behavior in experiments using covert or explicit leaders to steer or split a real crowd.