

Different ways of coordinating behavioral repertoires in crowds

Anna Sieben^{*1,2}, Mira Küpper^{1,2}, Tom Postmes³, and Armin Seyfried^{1,2}

¹Forschungszentrum Jülich, Institute for Advanced Simulation (IAS-7), Germany

²Bergische Universität Wuppertal

³University of Groningen, Faculty of Behavioural and Social Sciences, Netherlands

Abstract This study explores four modes of crowd coordination: mechanical (uniform movement with a leader or predefined choreography), physical (movement dictated by environmental constraints), organic (dynamic leadership in small interactive groups), and individual (independent movement requiring coordination to avoid collisions). Experiments manipulating physical and social factors confirmed that these modes influence crowd organization, movement patterns, and leadership dynamics. The findings highlight how different coordination modes shape crowd behavior, contributing to varying levels of homogeneity and heterogeneity in movement.

Keywords Behavioral repertoires, Crowd movement, Coordination, Crowd experiments

Movement repertoires in pedestrian behavior

Questions about the supposed homogeneity and heterogeneity of crowd behavior may be more than a century old, but they remain a central puzzle for our field. In prior research we have developed an analytical framework to describe and understand the different movement behaviours seen in crowds [1]. Based on past behavioral observation work [2, 3] we developed a method which focuses on forms of behavior seen in crowds that observers and participants are likely to see as socially meaningful. We call these behavioral repertoires. Some repertoires are specific for individuals (standing aside), some for small interactive subgroups (chatting) and some for larger subgroups (queueing). The fact that these behaviours are socially meaningful to participants and onlookers is consequential: it means that all involved have cultural and embodied understandings not just of how to move in relation to other actors, but also what norms apply, what atmosphere and emotions are fitting, etc.

Current research: Coordination in crowds

The transitions between these ways of behaving can occur fluently, typically without overt gesturing, and sometimes rapidly [1]. This raises the question: how do these patterns emerge and propagate? To study this, we conducted a set of small experiments (20-30 participants). We directly manipulated the physical, collective and inter-personal factors by which we hypothesize crowds coordinate their movement. We hypothesise that there is not one way to coordinate in crowds but several, and that each mode of coordination has its own characteristic pathways for social organisation. First, members of a crowd can feel as one and intend to move in uniform (collective/mechanical). In this case, the movement could be choreographed from the beginning (a dance performance in which everyone knows the steps, marching soldiers who know the drill) or there could be an initiator or ‘leader’. Second, members can move uniformly for non-social reasons, for example when the physics of the situation forces them to form lanes or keep a certain formation, speed or distance (physical). They may orient themselves to relevant physical cues, or coordinate with other people’s bodies and movement. Third, crowd coordination can start from interactive dyads or small groups who communicate, often non-verbally, how they are going to move together (organic). In this configuration, leadership is dynamic and there are potentially several leaders of small groups in the crowd. Finally, people can move within a crowd on their own, following their own rhythm but still, they need to coordinate to avoid collisions or blockages (individual).

In our analysis of the experiment we have tried to include and where possible integrate the physical and social psychological characteristics of the movement in each of these four conditions. Thus, we have developed a set of quantitative movement parameters to describe the different forms of coordination, unity and ‘leadership’. These results are complemented by post-experimental questionnaires which shed light

*Email of the corresponding author: an.sieben@fz-juelich.de

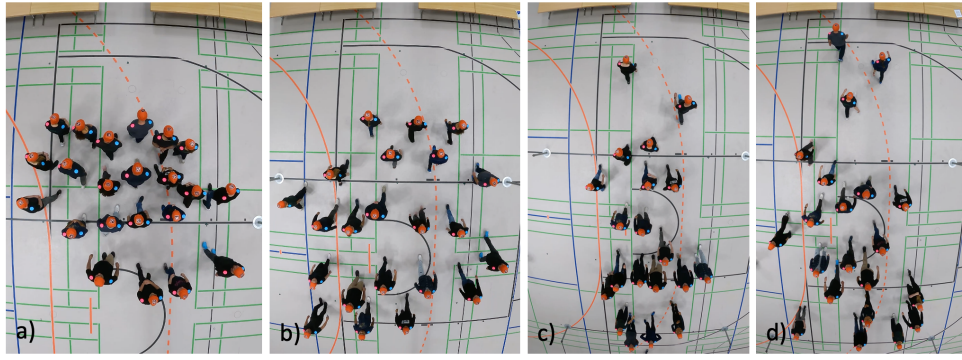


Figure 1: Coordination of movement: a) collective/mechanical, b) physical, c) organic/small groups, d) individual.

on the subjective experience of these variables. Finally, with qualitative analysis of observational data, we dig deeper into the behavioral dynamics of coordination and leadership across the four conditions.

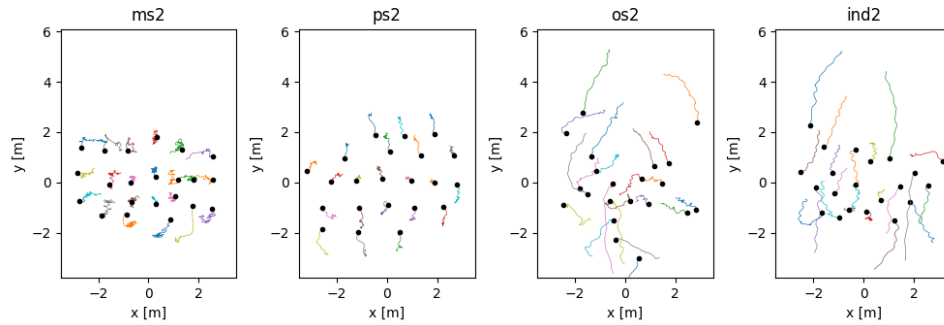


Figure 2: Crowd synchrony plots. In order to visualise the relative changes in position of the participants in relation to one another, the graph shows the ‘trajectories’ of the centre of mass system (center of mass at $(x,y) = (0,0)$). Conditions from left to right: ‘mechanical’, ‘physical’, ‘organic’ and ‘individual’. While the relative positions change only slightly for the condition ‘mechanical’ and ‘physical’, the variation is significant for the individual and organic conditions. In the organic condition, parallel trajectories indicate the movement of small groups or couples.

Together, the results suggest that it is useful to distinguish between these four modes of coordination in crowds, that these coordination modes are consequential for the kinds of actions displayed and hence also for the degree of homogeneity and heterogeneity found in crowds, and that these coordination modes are associated with fundamentally different ways of attending and responding to others, their movements and gestures.

Bibliography

- [1] Sieben, A., Postmes, T. *Behavioural repertoires in moving crowds: an observational approach*, Royal Society Open Science **12**(2), 241561, 2025.
- [2] Philpot, R., Levine, M. *Evacuation Behavior in a Subway Train Emergency: A Video-based Analysis*, Environ Behav. **54**(2), 383–411, 2022.
- [3] Schweingruber, D., McPhail, C., *A Method for Systematically Observing and Recording Collective Action*, Social Methods Res. **27**(4), 451–98, 1999.