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The generative role of noise in shaping social habits

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ABSTRACT

Social habits are most readily associated with synchrony, coordination, and the smooth flow of social interaction. This paper offers a complementary perspective, proposing that noise – moments of desynchronization, error, perturbation, stress, surprise – can be a generative force that drives the emergence and maintenance of social habits. We develop our account by drawing on recent work exploring the conditions necessary for noise to play a generative role in living and non-living systems and an autoethnographic account of a dyad repeatedly "running together" over an extended period of time. Combining these, we make the case for how noise can shape processes of social habit making at diverse timescales. Ultimately, this perspective reconcieves social habits as dynamic and multiscale alignments and highlights the generative potential of noise in supporting realignments across the levels and scales of human life. By placing noise at the heart of social habit formation, this paper offers an account of how through open-ended cycles of disruption and recovery minimal social systems adapt to their environments across scales.

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Introduction

One of the authors once worked in a shared office space across the hall from another space, separated by a communal kitchen. One day, while grabbing lunch, he found himself in the kitchen with someone from the other office – someone he had never spoken to before but had been crossing paths with for a while. On this particular day, having just initiated their first ever conversation with some pleasantries, they discovered the microwave they were both anticipating heating their lunch with was broken. Initially, the broken microwave was a disruption, a source of noise that interrupted what might have been the anticipated conversational flow under normal conditions. But it quickly became a shared focus of attention, animating their interactions with more lively conversation, heightened emotions, and mutual displays of coordinated sensorimotor curiosity, all anchored in a dynamic of playful contempt for the microwave's failure. The problem was, so powerful were the constraints of the microwave in supporting the interaction that followed, and absent any other shared experience, they struggled, thereafter, to get past it. In other words, despite initially being a source of noise, the microwave became an organising frame for their relationship that drew them into its orbit any time they encountered each other again. Anticipating future interactions, they each even developed a mild interest in microwave technologies; enough that they were able to advise management on the purchase of a replacement model. And even after they did eventually expand their conversational repertoire, the microwave persisted as a dependable fallback – a pattern that remained particularly salient any time they found themselves in the kitchen together again.

This anecdote embeds many of the themes we want to explore in this article. It highlights how shared habitual patterns emerge and stabilize through interaction, creating alignments within and between individuals and their environments. It also underscores the generative role of noise in catalyzing such processes: the broken microwave did not simply interrupt an otherwise smooth interaction; it provided the

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conditions for new dynamics between the interactants and their shared environment to emerge and for novel habitual patterns to take root. These are ideas we will consider in some detail below. Importantly, however, although we draw on recent insights around the generative role of noise in complex adaptive systems to develop our account, it is situated within and informs a broader and more protracted discussion around habits in social interaction, with notable contributions from thinkers like John Dewey (1925), Maurice Merleau-Ponty (1962), and Pierre Bourdieu (1977, 1984). All three offer rich and largely commensurate accounts of social habits, rooted in an organicist tradition, though they differ in emphasis – particularly when it comes to the dynamics of interaction and its role in the production and reproduction of these patterns. As such, some brief reflection on the values and limits of these accounts is also in order and will help better position our own efforts.

The 'recent work' we refer to above comes from many different domains and concerns insights that are understood to hold across many different levels and scales of living and non-living systems. However, we draw heavily on work from a few sources in particular: Roli et al, (2024) who have recently introduced some distinctions around the necessary conditions for noise to function generatively in complex systems; Laroche et al. who consider the value of desynchronisation to creative acts, also in social contexts; and Mayo and Gordon (2020) who have done work looking at the ubiquity of processes of synchronization and desynchronization in the coordination of social interactions in human beings. Social interactions are one prototypical example of complex adaptive systems and, as we will contend, demonstrate all the characteristics necessary for a system in which noise can play a generative role. Given that, we ask: does noise contribute to the adaptive creativity of social systems, enabling them to better attune to and align with their environments across multiple timescales? In summary, we answer that noise can serve to catalyze the emergence and reproduction of alignments by destabilizing and reconfiguring interactional patterns that organize into shared habits at different levels and scales.

To ground the discussion of social habits and the generative role of noise, this paper draws substantially on an autoethnographic study of running together by Allen-Collinson and Hockey (2017). Their investigation provides an example of how recurrent interactions generate stable patterns of coordination and shared meaning across multiple timescales. Allen-Collinson and Hockey note that "Running together necessitates a constant reciprocity of attention and an ongoing and mutual adjustment of rhythm and pace … Running together demands of co-runners considerable interactional work" (2017, p. 173). The 'interactional work' they refer to here is effectively the need to adaptively engage with the noise that is generated in the process of running together. Their detailed longitudinal account reveals how recurrent interactions stabilize into habitual relationship-specific patterns at various scales. By analyzing their account in line with the other distinctions we draw from, we provide support for the role of noise in both the emergence, adaptation and reinforcement of social habits at various scales[1].

This paper begins by briefly reflecting on the discussion of social habits as it is found in the work of Dewey, Merleau-Ponty and Bourdieu, highlighting what it views to be the primary limitations with such accounts. From there we consider the more recent theoretical perspectives from embodied cognitive science that have looked at the question of social habits, with an emphasis on situated interaction dynamics in recurrent social interactions. We then examine the necessary conditions for noise to play a constructive role: multilevel organization, redundancy, incompleteness, and criticality. Building on this foundation, we analyze the dynamics of habit formation across different timescales, from immediate adjustments to extended coordinative structures. Using the example of co-runners navigating shared challenges, we illustrate how noise catalyzes coordination and adaptation at short, medium, long, and extended scales, relatively speaking. Having done this, we also make the case for the endogenous production of generative noise and consider the ways in which it serves processes of multiscale realignment. Through this analysis, we aim to demonstrate that noise is not merely a disruption or something we need to cope with, but is an essential driver of the emergence and reproduction of adaptive social habits: robust, flexible, and multiscale patterns that support coordinated improvisations and that provide the basic units of social life.

Theoretical foundations

A potted tour of social habits

Pierre Bourdieu

Pierre Bourdieu's notion of 'habitus' remains one of the most influential and widely discussed accounts of socially patterned habitual behavior. Bourdieu himself describes habitus – perhaps a little inelegantly – as "structured structures predisposed to function as structuring structures" (Bourdieu, 1977, p. 72). By this, he means that the dispositions, preferences, and inclinations of individuals are shaped by the social and historical conditions they inhabit, but these dispositions in turn serve to reproduce the very structures that formed them. Habitus are, in this way, recursive and generative: social conditions are inscribed into bodily ways of being, which then guide thought, perception, and action, and are thus reinscribed in the social structure. These dispositions operate largely outside conscious awareness, providing individuals with a "feel for the game" (Bourdieu, 1990, p. 66) as they navigate their social worlds. For Bourdieu, habitus is not a simple reflexive response to stimuli but a flexible and purposive disposition, akin to a skilled craftsperson's intuitive know-how. By framing habitus as flexible and adaptive rather than mechanical, Bourdieu allows for the incorporation of intelligence and creativity into socially structured action.

There is, however, a fundamental ambiguity in Bourdieu's account: while habitus captures the structural consistency apparent in the practices of specific social groups, it says little about the situated processes of emergence and reproduction that generate these patterns in the first place. For example, in *Distinction* (Bourdieu, 1984), Bourdieu explores how class "tastes" and dispositions – like the "tight-lipped" eating style of the bourgeoisie – are inculcated and embodied, yet he stops short of offering a detailed mechanism for how such patterns propagate through interactional dynamics. As Crossley (2013) critiques, "the formation of habitus at both the individual and collective levels is at best glossed over" (p. 147). Bourdieu's account remains concerned with macro-social determinants of habitus, historical structures, class dynamics, and fields of power, while neglecting the microdynamics (or perhaps *meso* – see Secchi et al., 2022) of interaction through which habitus take shape in lived experience. This limitation invites the need for a more situated, process-oriented understanding of social habits, one capable of capturing their emergent, relational nature in social interaction.

Maurice Merleau-Ponty

Merleau-Ponty offers a dynamic and embodied account of habit that goes some way to addressing this limitation. Merleau-Ponty famously writes that knowledge is "in the hands" (1962, p. 144), emphasizing – similar to Bourdieu – how habits reflect a practical, pre-reflective understanding of the world. Through habit, the body "absorbs a new meaning and assimilates a fresh core of significance" (ibid, p. 146). This process is developmental and dynamic: habits form when an actor finds a new, stable way of handling the world, but this stability is always open to reconfiguration through ongoing action. As Crossley (2013, p. 149) puts it: "Habit arises when we arrive at a new (relatively stable) way of handling or using the world, which in turn then constitutes its meaning differently for us". The development of habits then might be seen as a function of a kind of psychological allostasis: our ability to adapt our homeostatic set point in response to the regularities of stresses in our environments.

Merleau-Ponty also recognized that habits are inherently social. The patterns we acquire through habit are always infused with the traces of others' actions. The intersubjective nature of habit means that our ways of being in the world are collectively shaped – they derive from a common social repertoire of practices, meanings, and norms. In this way, habit bridges the individual and the collective. Crossley reflects this point when he writes that "Insofar as these habits are shared institutions … the meanings in question are intersubjective" (2013, p. 149). And so, for Merleau-Ponty the continuity of self and culture is tied together in the notion of habit. Habits enable us to maintain a sense of identity across time, allowing us to "start again tomorrow where we left off today", but it also "lends this same continuity to collective history and culture. We are not just creatures of habit but also creatures of culture and fundamentally historical beings who reflect the historical epoch to which we belong in all that we do, think, perceive, and say" (ibid, p. 146). Despite the richness of Merleau-Ponty's account of habits, it too suffers from a critical limitation. While he offers a developmental and embodied understanding of individual

habit formation, sees habits as the means by which we gear into larger collectives, and has elsewhere elaborated on the foundational role of situated social interactions in his notion of *intercorporeality* – he never brings these elements together to consider the emergence and reproduction of social habits in recurrent social interactions. In short, as with Bourdieu, he does not provide a detailed account of how the habits of one person form in interaction with another agent over time.

John Dewey

Dewey also explicitly recognized the social origins of habit. For Dewey, all habits are fundamentally social insofar as they emerge through interactions within shared environments and are subject to ongoing social reinforcement. Habits are ways of incorporating the environment, which includes not only the material world but also the social world of customs, sanctions, and collective expectations (Bedia et al., 2019, p. 343). Dewey's position is significant because it identifies social interaction as the key mechanism for habit formation. As Crossley (2013) points out, Dewey moves beyond Merleau-Ponty by acknowledging that interactions often involve other actors, and thus habits "emerge from and belong to the collective life of human beings" and are shaped "in the to and fro of social interaction" (p. 152). This collective dimension is especially evident in Dewey's reflections on social groups. He argues that interactions within relatively closed networks of people – such as working-class communities – generate distinct collective habits and lifestyles. The regularity of interaction within these networks stabilizes shared practices, enabling groups to develop their own "working morals".

However, Dewey's account, while offering valuable insights, also remains incomplete for a couple of reasons. First, while he identifies social interaction as central to the emergence of shared habits, he does not develop a sufficiently dynamic or detailed account of this process. The to and fro of social interaction remains somewhat abstract in Dewey's work, and there is little elaboration on the finer-grained coordination dynamics through which shared habits stabilize and propagate. Second, for Dewey, conflicts between groups with differing habits are seen as disruptive, but he does not fully explore how these disruptions might also serve as opportunities for novel alignments or the emergence of new shared habits. As such, while Dewey's account goes some way to acknowledging the dynamics entailed in collective habit formation, it lacks the developmental and interactional detail necessary to account for the emergence, recalibration, and reproduction of shared habits over time.

Embodied cognition

To address these gaps, embodied approaches have offered more dynamic, situated and interactional perspectives on the functioning of habits in social life. In *Linguistic Bodies*, Di Paolo et al. (2018; also drawing on earlier work, e.g. De Jaegher & Di Paolo 2007; Cuffari et al., 2015; Froese & Di Paolo 2011) describe social interactions as emergent autonomous domains of activity where agents co-regulate their behaviors in response to one another and the maintenance of the interactive system as a whole. The example of two people getting caught in an interaction they struggle to get out of is an illustrative example of the emergent autonomy of social interactions. Here, meaning arises through a "relational dynamical process" (Di Paolo et al., 2018, p. 96), emphasizing the affective, sensorimotor and linguistic coupling between participants as the foundation for shared understanding. Through navigating and resolving, or attempting to resolve, a series of tensions that arise in social interaction – between the individuals involved and the interaction processes themselves – human beings are inclined towards evermore complex forms of coordination. Eventually this coordination gives rise to language and all of the social conventions and institutions that come with it. Drawing on these and related ideas – e.g. Bolis & Schilbach 2020; Fuchs 2017; Fusaroli et al., 2014; James & Loaiza 2020; Jurgens & Kirchhoff 2019; McGann 2014; Ramseyer & Tschacher, 2011; Riley et al. 2011. James (2021) has argued that as these interactions become recurrent they begin to generate coordinative structures that, through repetition, become stabilized and reinforced within the dynamics of the interaction itself, taking on their own dynamics of autonomous self-production, i.e. habits that belong to the social system itself.

This work builds on an organicist notion of habit whereby habits and more encompassing networks of habits (e.g. schemes, routines, micro-identities) function like miniature lifeforms, taking on a life of their own, reproducing their own organisations by the activities they motivate (see Barandiaran, 2017;

Barandiaran & Di Paolo 2014; Di Paolo et al., 2017; Egbert & Barandiaran 2014; Egbert & Cañamero 2014; Ramírez-Vizcaya & Froese, 2019). Herein, habits are understood as a kind of bridging category between life and mind. These are, in effect, nested homeostatic processes, or circularities of constraints (James 2020a; Loaiza et al., 2020), that when aggregated together form a kind of habit ecology that evolves through processes of euqilibration and allostatic regulation. Within this account, development, learning and change reflect the evolution of this habit ecology. But, crucially, this ecology does not stop at the limits of an individual person. As people interact together over time, shared-habits, shared routines and inter-identities also evolve, creating larger, overlapping and intersecting ecologies (James 2021; James & Loaiza 2020). These ecologies help people improvise with each other and the situations within which they repeatedly act together. Such interpersonal dynamics are the basic constituents of social life. This work highlights the mutual interdependence of agents and their sociomaterial contexts, framing interaction not as a secondary feature of social life but as its primary mode and site of its production and reproduction. As such, we can say that habits not only provide a bridging category between biological life and psychological life, but also social life. Indeed, habits are, we might say, the means by which we establish and maintain functional alignments between these different dimensions of being and becoming.

In all of this work although the dynamics of coordination, synchrony, and coupling are foregrounded, the generative role of noise in shaping these processes is also apparent. De Jaegher and Di Paolo (2007), for instance, describe "interruptions of ongoing interaction that serve as opportunities for participants to re-establish coordination in novel ways" (p. 492). Nevertheless, the noisey moments are treated as secondary in such accounts, with limited formal elaboration on how they contribute to the production of social habits, beyond being tensions of various sorts that require some sort of resolution (Di Paolo et al., 2018). Furthermore, noise is typically considered as arising from exogenous sources, such as the environment (as in the microwave example), or misaligned coordination efforts of some sort. Herein, however, we also explore the possibility that the exertion of agential regulation is itself a source of generative noise. From this perspective, noisy disruptions are not limited to events that happen, but can also be deliberate doings, wherein they become resources employed by interacting agents to support coordination across varying timescales– setting a boundary in a friendship or romantic relationship is an intuitive and perhaps quite explicit example. We will consider many more in the sections that follow.

Noise and generativity

The notion of noise we are working with here speaks to a destabilization in the ongoing patterns of coordination, communication, and functioning within a system. Here, noise can be broadly interchanged with error, perturbation, desynchronization, shock, surprise, and stress – though some of these terms will be more appropriate in certain contexts than others. Ostensibly, all are noteworthy for their negative connotations. As Roli et al. put it, "Noise and error are usually considered to be disturbances negatively affecting the behavior of a system" (2024, p. 2). This framing has deep roots, most notably in Shannon's (1948) information theory, where noise is modeled as an external disturbance that interferes with signal transmission, something to be filtered out or corrected in order to preserve message fidelity. This understanding has extended metaphorically across disciplines: in many cases, noise is equated with the notion of white noise, a flat, undifferentiated randomness that obscures signal and disrupts meaning. Whether internal or external, it is treated as a background condition that systems must work against.

Of course, this view is not without justification: noise can indeed degrade or significantly diminish a system's functioning, even leading to its collapse. But sometimes, what manifests as noise at one scale or in one location may prove adaptive at longer timescales or when viewed in relation to the whole system (see also McGann, forthcoming, for a rich account of the relative generativity of noise in living systems). As Roli et al. note – following on from the previous quote – "Nevertheless, from a systemic perspective, … noise and error may assume a creative, constructive, and positive role in that they are a source of novelty that can trigger the reorganization of the system, the growth of complexity, and the emergence of new meaning" (ibid, p. 2). Laroche et al. (p. 3) echo a similar sentiment when they write that "… de-synchronized states, by conjuring uncertainty, provide opportunities of reorganization into novel and useful patterns".

But in what ways, and under what conditions? Some responses to these questions have already been offered by these and other researchers[2]. Here, we take up these ideas more explicitly in the context of social interaction and the emergence of social habits. To do so, we first consider the conditions under which noise can play a generative role, and then ask whether social interactions afford these conditions. Only after that can we explore how noise actually functions within recurrent interactions to support the shaping of social habits across multiple timescales.

Conditions for generative noise

Roli et al. (2024, p. 9) reflecting on the existing literature around the generative role of noise in complex systems, contend that "[o]ne of the main effects of noise and error is that they can be sources of novelty". However, as they continue, "[t]he question arises as to what the conditions are that enable noise and errors to generate novelty and have a positive impact on the system". They propose four conditions: *multilevel interactions*, *redundancy*, *incompleteness* and *criticality*. Here, we briefly review each condition, beginning with the notion of multilevel interactions, and follow each by considering them in the context of social interactions. See Table 1 below for a helpful summary of the conditions, their relationship to the notion of noise and how they show up in social interactions.

Multi-level organization

Roli et al. (2024) describe multilevel organization as a critical property of systems that enables them to integrate noise constructively. In their framework, multilevel organization refers to the dynamic interactions between different hierarchical layers of a system – ranging, for instance, from molecular to organismal levels in biological systems, or from sensory inputs to task-level behaviors in artificial systems. They argue that these interdependent levels provide a context in which noise catalyzes structural changes and adaptive responses. Their claim is that noise acquires value in a multilevel system in that what constitutes an error at one level can be reused by the dynamics at another level in a way that has some creative potential. They describe, for instance, how protein synthesis variance generates novel proteins, some of which are seized by higher-level biological processes to create new affordances – opportunities for action that emerge in the relationship between agent and environment (Chemero 2009; Gibson 1979) – enabling evolutionary adaptation.

Consider the opposite: in a single-level system, noise would simply disrupt the processes at that level without creating opportunities for higher-order interpretations or adaptations. For instance, imagine a simple thermostat regulating room temperature: if its sensor receives faulty input, it may turn the heating on or off at the wrong time, resulting in uncomfortable conditions. The system has no means of

Table 1. The rows in this table refer to the conditions, drawn from roli et al., that allow noise to play a generative role in complex systems.

Condition	Definition	Interaction with noise	Example in social interactions
Multilevel Organization	The hierarchical structure of a system, where different levels interact and co-constrain each other over time.	Noise at one level can cascade to others, triggering systemic adaptations and generating novel patterns of organization.	Breakdowns in small-scale interactions (e.g. dialogue) can influence broader dynamics (e.g. shared goals), supporting constructive realignments.
Redundancy	Overlapping components or functions that ensure robustness and adaptability in the presence of failures of a given component or function.	Noise or disruptions are absorbed by redundant elements, which maintain system functionality while enabling exploration of alternative pathways.	Facilitates e.g. conversational repair, role flexibility, and resilience in maintaining interactional coordination during disruptions of a given channel.
Incompleteness	A system's lack of full specification, allowing multiple, non-equivalent pathways and outcomes.	Noise introduces variability, pushing the system to explore alternative configurations and exploration of the "adjacent possible."	Enables open-ended exploration of the possibility space, supporting the emergence of novelty and the co-construction of new meanings.
Criticality	The ability of a system to operate near a tipping point, balancing stability and flexibility to explore novel configurations.	Noise can push and keep the system near critical thresholds, enabling the amplification of weak signals and adaptive reorganizations.	Allows for small events to be scaled up in meaningful ways that can support adative function, e.g. a momentary laugh breaks a tense dynamic in a way that supports conflict resolution.

The columns offer definitions of each condition, their interaction with noise, and examples of how these come together in social interactions.

learning from the error. In a multilevel system – such as a human body – thermal deviations at one level, can trigger behavioral adjustments (putting on a sweater), environmental modifications (adjusting the thermostat settings), social coordinations (asking someone else to fix it), and so on, each operating at different levels that together support resilience and the adaptation of the whole. In short, in multiscale systems, noise at one level introduces variability that other levels can interpret, stabilize, or adaptively integrate into the system's dynamics.

This feature of multilevel organization is readily apparent in social interactions. Consider, for instance, De Jaegher and Di Paolo's very definition of a social interaction, what they describe as: "The regulated coupling between at least two autonomous agents, where the regulation is aimed at aspects of the coupling itself so that it constitutes an emergent autonomous organization in the domain of relational dynamics" (De Jaegher & Di Paolo, 2007, p. 493). Here, the multilevel organization of the interaction is built into the very definition, where at least two levels of autonomous organization are present simultaneously, individual and interactional (but of course there are also many more too).

Let's consider an example in which noise in a multilevel interaction enables an adaptive evolution in a social dynamic. Imagine that in a team meeting someone disrupts the established conversational flow with a comment about something they have to do later, but have just been reminded of by their calendar. The comment introduces some strain at the level of the ongoing dialogue, taking things off course. However, at the level of the group orienting towards their project goals, the comment sparks a shift in thinking that allows the conversation to take a new direction, which turns out to be promising. As such, noise at the level of linguistic utterances within the group catalyzes a change in group dynamics that leads to some innovation that might not have been arrived at; noise allows the group to seize on some set of affordances that otherwise may never have been revealed.

Other more intentional disruptions may also work inside these multilevel dynamics, e.g. when in a heated argument that appears to be going around in circles someone makes a conscious effort to slow down and find some space from their emotions. Here, one individual's slowing down is a source of noise within the ongoing emergent social dynamic, but it, perhaps, allows for the emergence of more subtle and previously backgrounded affective possibilities to shine through, recovering the interaction along more considerate and caring trajectories.

Within social interaction there are many levels of interactional dynamics that we know to be capable of and generally disposed toward coupling together, e.g. neuronal, endocrine, affective, sensorimotor, gestural, and linguistic; each of which might even have their own nested levels (see Mayo & Gordon 2020 for discussion; see also Cummins 2009, 2010, 2019; Dumas 2011; Dumas et al., 2010; Riley et al., 2011; Schilbach et al., 2013). Noise in any particular dynamic can spill over into the others and be taken up as a catalyst for some sort of generative purposes. Micro-level disruptions, such as desynchronization in inter-neural activity (e.g. interbrain desynchrony), may allow for more personal autonomy at the level of the interacting individuals, providing opportunities for recalibration or deeper alignment. At the meso-level, group coordination during collective improvisation – such as in music or dance – can be disrupted by a misstep or unexpected variation. As Laroche et al. observe, such disruptions are not merely obstacles but are often seized by participants to explore novel configurations, driving creativity and cohesion at the group level and even leading to creative breakthroughs and, for instance, a re-articulation of what is possible in such a context. On the macro level, shared norms and practices can undergo transformation through significant disruptions at other scales, e.g. the loss of a group member[3].

Redundancy

Redundancy supports adaptability and robustness within complex systems by providing overlapping functions and alternative pathways for action. It enables a system to reorganize in the face of disruption without losing coherence or functionality. When one component fails, others can take over – for example, if one arm is immobilized while swimming, coordination between the remaining arm and the legs can still maintain propulsion. This principle applies across both artificial and living systems. In artificial neural networks, redundancy enables the system to adjust internal weights in response to unreliable inputs, maintaining responsiveness to new stimuli while preserving existing functions. Roli et al. (2024) describe a robot performing phototaxis – movement toward a light source – despite receiving ambiguous information from faulty sensors. The robot adapted its behavior by reorganizing its internal network

to filter out irrelevant noise. As they put it, "redundancy makes it possible to change U by reusing, rearranging, and recombining the objects already contained in U" (p. 7). Biological systems rely on a similar principle. In evolution, functional overlap among proteins means that mutations can be tolerated and even explored without immediately threatening the organism's viability. If one protein is disrupted, others can compensate, allowing the mutation to persist and potentially contribute to adaptive innovation. Redundancy enables such systems to maintain essential functions while remaining open to transformation. As Roli et al. note, it allows a complex system to rearrange its "structures and processes so that [it] is able to create new meanings" (p. 7).

Crucially, this capacity for reorganization depends on the system having internal structure. Roli et al. contrast redundancy with the concept of maximum entropy – a state in which all components are equally probable and no constraints shape the system's dynamics. In such a condition, the system lacks differentiation, overlap, or scaffolding to guide adaptive change. There is nothing to recombine or repurpose. Redundancy, by contrast, embeds flexibility within structure. It equips the system with the internal resources to preserve what works while selectively responding to new demands.

In social interactions, redundancy operates in much the same way. For example, in conversations, rephrasing a miscommunicated message may allow interactants to navigate misunderstandings and reestablish coherence. Such rephrasing not only resolves immediate ambiguity but may also lead to novel insights or deeper mutual understanding. Given the multilevel organization of social interactions spoken about previously, we can see that there is actually a huge amount of redundancy in such systems. If we presume that any social interaction is at least minimally organized along a tendency to "get along" and continually recover a kind of interactional stability, we can see that, for instance, breakdowns in linguistic communication can be compensated for by bodily gestures (e.g. someone gives a hug when they can't find the language to say sorry); or a mistimed gesture needn't threaten the stability of in the interactive dynamic as a whole if there are strong positive interaffective resonances present (Fuchs, 2016). By leveraging redundancy, noise in social interactions – such as miscommunications or unexpected actions – can be transformed into opportunities for generative reorganizations that explore more of the richness of the possibility space of the interaction, thereby maintaining an existing course of action in an creative manner, or uncovering a novel one better suited to situational demands.

The experience of awkwardness in social interaction offers a clear example of how redundancy operates in interpersonal coupling. Some aspects of the interaction may be successfully coordinating, while others are misaligned. Not all awkward encounters lead to novelty, of course, but many social interactions that do produce something new pass through phases of awkwardness or miscoordination. There is a growing body of work that frames awkwardness as an important affective mode for navigating increasingly globalised and intercultural settings, where shared norms cannot be assumed, but the desire to maintain convivial social relations is apparent (James 2020b, 2021; Kotsko 2010). Interestingly, in certain cultural contexts, this generative function of social disruption is not only recognised but actively cultivated. In Ireland, for example, this is evident in the cultural practice of *the craic,* where unpredictability, playful contradiction, and moments of rupture are often treated as signs of a successful interaction. Rather than aiming for seamless rapport, the interaction is shaped around disruption and recovery. These forms of engagement rely on high degrees of redundancy within the social system, allowing interactions to absorb noise without collapse and reorganise dynamically in response. Over time, practices like this may support the development of culturally embedded dispositions that favour flexibility and responsiveness, enabling individuals and communities to remain attuned to shifting conditions and to act within them. As the journalist Fintan O'Toole (2022) has recently argued, the Irish cultural psyche has long been shaped by an ability to navigate contradiction and discontinuity, often under conditions of external constraint. Similar dynamics can be observed in other cultural contexts shaped by histories of colonialism or marginalisation, where irony, indirectness, and improvisation operate as adaptive strategies for managing asymmetrical relations and maintaining cohesion (Bhabha 1994; Glissant 1997; Scott 1990).

Incompleteness

Incompleteness is a defining feature of many complex adaptive systems, referring to their inherent flexibility and lack of full specification. Unlike systems constrained by rigid, predefined rules – such as those in a

traditional assembly line where each component performs a fixed, predetermined function – incomplete systems exhibit the capacity to evolve through multiple pathways, always having other possibilities for their action. This property ensures adaptability, as the structures and behaviors of such systems can dynamically reorganize in response to changing conditions. Roli et al. (2024) emphasize that incompleteness allows systems to "[p]rovide new interpretations of external and internal stimuli because the processes in the system are not univocally specified and can be executed by following alternative, non-equivalent paths" (p. 7). Whereas redundancy largely concerns how a system maintains a given course of action (e.g. reliably responding to some stimuli) in the presence of some failure, incompleteness allows, in principle at least, for multiple responses to the same stimuli, reflecting the inherent flexibility of the system. It is worth noting that incompleteness governs a system's internal flexibility, but its ability to engage dynamically with the environment relies on a related property: *logical openness*. Logical openness refers to a system's capacity to incorporate and adapt to external inputs, shaping its internal dynamics through interaction with its surroundings. Together, these properties enable complex systems to reorganize internally while responding to external disruptions.

In biological systems, this dynamic plays out in the interactions between genetic variation and selection. Mutations introduce variability at the molecular level, often with disruptive effects in the short term. However, this variability becomes a resource for adaptation when processed through higher-order regulatory and selective mechanisms. In such cases, incompleteness at one level is enabled and leveraged by incompleteness and logical openness at another. The system's internal flexibility allows for multiple potential responses, while its capacity to engage with environmental input enables those responses to be evaluated and shaped over time. This dynamic facilitates the exploration of *adjacent possibles* – new system configurations that are viable from the current state but not strictly determined by it (Kauffman 2000). A similar pattern appears in artificial neural networks. Stochastic variation introduced during training, such as dropout or noise in weight initialization, helps the model avoid premature convergence on suboptimal solutions (Srivastava et al., 2014). In these contexts, incompleteness allows the system to explore a broader solution space, while feedback mechanisms grounded in environmental interaction guide it toward more functional configurations. In both biological and artificial domains, incompleteness enhances a system's adaptability by maintaining internal flexibility – it ensures that the system can still produce context-sensitive responses when conditions change, rather than being constrained to a fixed repertoire of actions.

Social interactions exemplify incomplete and logically open systems too, as their outcomes are not predetermined, but emerge dynamically through mutual adjustments and co-regulation between interactants relative to their environments, shared goals and individual needs. For example, cultural norms and environmental scaffolds act as constraints that shape the dynamics of interactions, but they do not specify it completely. Instead, they provide a context for the interaction, while still allowing for the flexibility and improvisation inherent to incompleteness. This ensures that responses remain adaptive and contingent to the specifics of the situation, which may be in principle impossible to specify or anticipate in advance. Such incompleteness also allows the system to retain a generative tension; as Laroche et al. emphasize: "Incompleteness of relational dynamics keeps the interaction moving forward." (p. 7). Roli et al. (2024) illustrate this dynamic with the example of musical improvisation, when they write, "A new melody produced by mistake by a musician can be subsequently used as a pattern by other musicians. As is often said among musicians: 'It's not the note you play that's the wrong note: it's the note you play afterwards that makes it right or wrong'" (p. 7). Thus, given the incompleteness of social interactions, moments of noise – such as hesitations, interruptions, misunderstandings, or missteps – are opportunities for reinterpretation and co-creation; means of revealing adjacent possibilities in the ongoing flow of the social interaction.

Some of the endogenously produced noise described above also draws on, and makes use of, the incompleteness and openness of social interaction. Awkwardness, for example, can have value not only in sustaining interaction under conditions of tension or uncertainty, but also as a way of disrupting entrenched patterns. When generated deliberately – such as by refusing to laugh at a sexist joke – it can function as a strategic interruption, creating a pause in coordination that opens the space for new trajectories to emerge (Ahmed 2017). These forms of disruption do not rely on redundancy to preserve the status quo; rather, they rely on the incompleteness and logical openness of the interactional system,

which allows it to reorganise around new possibilities. Cultural practices like the craic too, and comparable cultural logics that value surprise and playful deviation, actively cultivate this orientation. Such practices draw on the incompleteness of the systems they organise, treating moments of rupture as opportunities for shared exploration. In doing so, they help sustain a mode of cultural engagement that resists premature closure, allowing cultures to remain adaptive and responsive without settling into overly rigid or constrictive forms[4].

Criticality

Criticality refers to a system's state at the transition between order and disorder, where it dynamically amplifies perturbations to balance stability and adaptability (Bak 2013). This poised state allows systems to remain responsive to change while maintaining functional coherence. As Roli et al. (2024) note, "Systems characterized by dynamical criticality achieve a balance between robust responses to stimuli and the ability to explore new configurations" (p. 8). Criticality is observed across diverse complex systems, from gene regulatory networks, where it enables transitions between stable states while preserving responsiveness to environmental conditions, to cortical networks in the brain, where it optimizes perception and learning by managing the integration and segregation of neural activity. Similarly, adaptive neural networks in robotics leverage criticality to detect meaningful patterns in noisy sensor data, dynamically reconfiguring in response to environmental changes. In such systems, the critical regime is typically tuned or designed, though recent efforts aim to allow them to self-organize toward this regime.

A hallmark of criticality is scale-free dynamics, in which activity follows power-law distributions: small events occur frequently, while larger events are rarer but more consequential. This structure ensures that small perturbations can propagate without overwhelming the system, while preserving the possibility that more significant fluctuations can reorganize it. The behavior of such systems can be compared to a pressure valve in how they manage fluctuations: critical systems naturally regulate both small and large events through their internal dynamics, allowing minor fluctuations to dissipate while accommodating larger reorganizations when they arise. Unlike a pressure valve responding to external forcing, however, critical systems self-organize to produce these dynamics, with events of all sizes emerging naturally as part of their operation.

Another defining feature of criticality is heightened sensitivity to weak inputs. Systems at criticality amplify small disturbances, sometimes leading to minor adjustments and other times triggering large-scale reorganizations. This inherent property allows critical systems to respond dynamically to their environment, but it also means they remain poised on the edge of stability, where both small and massive events are possible. In a subcritical state, inputs dissipate too quickly and weak signals are lost, while in a supercritical state, inputs trigger runaway cascades, overwhelming the system. At criticality, inputs propagate efficiently, shaping the system without losing overall coherence, though large-scale reorganisations remain possible. This enables adaptive systems to detect and amplify meaningful signals, while remaining sensitive to cascades of varying scale.

Noise plays a crucial role in maintaining criticality, serving as both a destabilizer and an amplifier. As Roli et al. (2024) summarize: "Criticality in multilevel systems nicely fits into frameworks of adaptation and meaning-making, allowing systems to cope with and exploit noise and errors" (p. 8). Noise amplifies meaningful signals through phenomena like stochastic resonance, whereby its presence enhances the sensitivity of the system to certain signals by pushing them over a threshold, allowing it to detect and respond to subtle changes that might otherwise remain below the level of responsiveness. A familiar example of this logic can be found in sound perception: a faint tone, when played on its own, may go unnoticed, but when layered over a bed of low-level white noise, it often becomes more perceptible. The noise introduces subtle fluctuations that the auditory system can use to identify the signal's structure, effectively bringing it into awareness.

While this is not a textbook instance of stochastic resonance in the narrow technical sense, it illustrates the broader principle: that under certain conditions, a weak signal can be made more detectable through the presence of noise. Beyond amplification, noise also plays a destabilizing role, helping systems escape rigid or subcritical patterns by pushing them to explore alternative pathways and configurations. As such, it supports the maintenance of criticality itself, as frequent micro-disruptions test the system's responsiveness and prevent it from settling into states that are either overly ordered or

excessively chaotic. In sum, criticality enables complex systems to operate at the edge of chaos, maximising responsiveness to weak inputs while preserving the capacity for large-scale reorganisation when necessary.

In social interactions, criticality plays a central role in enabling adaptability. Social interactions operate at a delicate balance, where subtle signals are sometimes amplified and significant perturbations are sometimes dampened. Within these systems, criticality manifests across many different dynamics, including affective, sensorimotor, and linguistic, and between various levels and scales. Think, for example, of a romantic interaction where a small gesture from one partner – a gentle touch or a lingering glance – suddenly unlocks a deep emotional response in the other and the sense that they might want to spend their life with this person. Or consider two friends sharing a moment of uncontrollable laughter triggered by something as trivial as a silly noise. The laughter seems disproportionate to the event itself and is reinforced through cascades of positive feedback. These examples highlight how social interactions, operating at criticality, are highly sensitive to small inputs, which can be appropriately amplified into meaningful outcomes.

Noise can emerge from a great manifold of sources in these systems in ways that play a generative role. Indeed, the generation and management of noise is built into the structure of meaning-making itself. Communication always involves some degree of ambiguity and interpretation; what is expressed is never exactly what is received. Even the most basic exchanges require real-time coordination, translation, and accommodation. Rather than being a flaw, then, this inherent indeterminacy supplies some of the background variability through which new meanings and relational shifts can emerge. But more specific examples are also apparent.

For instance, imagine a heated argument where one person misphrases a sentence, unintentionally creating a humorous interpretation. This momentary slip introduces noise into the interaction. But because the system is operating at criticality, this small disruption can ripple through the interaction, eliciting shared smiles, which in turn build on each other and momentarily diffuse the tension, satisfying a deeper need for conviviality within the interaction that had not been at the fore. The noise, rather than derailing the conversation, creates an opening for a productive reframing of the conflict when propagated and amplified through the smiles of the participants. The example of the craic is appropriate here too, where, for instance, small slips of the tongue or incidental events may be blown out of all proportion for their comedic effect. In sum, minor disruptions, amplified by the dynamics of criticality, can reverberate through the interaction, producing seemingly disproportionate effects on the trajectory of meaning-making that can sometimes be very generative. Criticality also prevents social systems from becoming overly rigid by keeping open the possibility that established norms or patterns can be revised through the amplification of noise. See Table 1 below for a helpful summary of the conditions that allow for noise to play a generative role, and their realisation in social interactions.

Noise and social habits

An autoethnographic account of recurrent social interaction

To explore the role of noise in the emergence and reproduction of social habits, we turn now to an empirical example drawn from collaborative autoethnographic work by Allen-Collinson and Hockey (2017). Wife and husband, research and running team, Allen-Collinson and Hockey investigated the emergence of a particular pattern of being together, what they call *running together*. Their study draws upon extensive embodied experience within the subculture of distance running and is grounded in a two-year co-autoethnographic project involving "daily (or almost daily) engagement … via field notebooks, training logs, micro-tape recorders and photographs … [and] … a joint analytic log" (Allen-Collinson & Hockey, 2017, pp. 177–178). Their resulting analysis is based on iterative reflection and discussion, informed by a sociological phenomenology that foregrounds lived experience, intercorporeality, and the pre-reflective dimensions of bodily coordination.

Their aim was to "explore and analyse in detail various intercorporeal practices and processes, fundamental to the enaction of training-together for distance running" (p. 173). Although they don't frame it in these terms, their account offers a detailed view of how shared habits develop through interpersonal

coordination and mutual adjustment over time. Central to their analysis is the emergence of an intercorporeally generated life-world – what they describe as arising through "pre-reflective and intuitive corporeal coordination" (p. 181) – that makes running together possible as a meaningful and sustained joint activity. Their empirical work offers valuable insight into the conditions under which social habits stabilize and are reinforced, and also, implicitly, into the generative role of noise and how disruptions, ambiguities, and momentary misalignments act as resources for ongoing adaptation and coordination.

The practice of running together thus provides a compelling case for how social habits emerge and evolve across multiple timescales. These include short-timescale interpersonal bodily cues (e.g. breathing or glances), medium-timescale adjustments to environmental conditions (e.g. synchronizing pace over uneven terrain), longer-timescale situational inter-identities (e.g. being running partners), and extended-timescale transituational inter-identities (e.g. being spouses and research collaborators). While the precise patterns highlighted are specific to the cultural and relational context of the authors, the case is illustrative of more general processes through which social coordination becomes sedimented into shared forms of life in recurrent social interactions. As such, it addresses the gaps with previous accounts of social habits/habitus highlighted earlier, by giving us insight into how these patterns take shape within minimal social systems in ways that also enable those systems to attune to the larger cultural patterns within which they are nested (for a more thorough account, but without the emphasis on noise per se, see James 2021; for sympathetic accounts related to the temporal dimensions of affordances, see Gastelum 2018, 2020).

In what follows, we draw on this empirical material to unpack how noise functions across these timescales as a constitutive and even necessary condition for the flexible stabilization of social habits. We present the dynamics of their shared practice in order of increasing duration, from momentary adjustments to extended inter-identities, highlighting how processes of sense-making and synchronization depend upon both ongoing attunements and the capacity to reliably metabolize noise.

Running together

Allen-Collinson and Hockey describe running together as a form of intercorporeal synchrony achieved by pairs running long distances. This synchrony, they explain, "necessitates a constant reciprocity of attention and an ongoing and mutual adjustment of rhythm and pace … Running together," they argue, "demands of co-runners considerable interactional work" (Allen-Collinson & Hockey, 2017, p. 173). Through this interactional work, the pair develops an intuitive sense of their partner's state – for example, when one is struggling – which animates them to co-regulate and sustain the dynamic of running together across different terrains. This process exemplifies a tendency toward a *co-optimal grip*, a mode of relating where the partners work to maintain a metastable whole, which allows them to be adaptively positioned relative to themselves, each other and their shared environment (see James & Loaiza 2020 for elaboration; for more on the notion of grip see Kiverstein et al., 2019).

This ability to maintain a co-optimal grip when running together is not merely a static feature of interaction but emerges through a history of shared activity. Allen-Collinson and Hockey note that, "Such attunement generally only occurs when runners have long-standing, sedimented knowledge and understanding of each other as running-beings" (2017, p. 180). In other words, this capacity is undergirded by repertoires of shared habits and mutually attuned capacities for improvisation. Such habits evolve through recurrent situated interactions, stabilizing into distinct forms that enable intuitive, pre-reflective coordination. Allen-Collinson and Hockey identify several forms of habitual organization, whose dynamics are nested within one another, with simpler habits forming the foundation for more complex, longer scale patterns. Running together, as a shared practice, integrates these layers of habitual organization, creating a metastable dynamic that allows the pair to adapt to shifting conditions while maintaining a coherent interactional identity.

By drawing on previously introduced conceptual developments and the detailed empirical insights of Allen-Collinson and Hockey, this section lays the foundation for understanding how noise may operate across timescales to shape the emergence and reproduction of social habits. It is important to note, however, that applying these formal ideas to these interactional dynamics remains a speculative exercise – a preliminary endeavor intended to refine our intuitions and guide subsequent empirical and experimental investigations. See Table 2 below for a summary overview of how the conditions that enable generative noise (Sec. 2) function at different timescales.

Table 2. Overview of how the conditions that enable generative noise function at different timescales.

Condition	Short timescales	Medium timescales	Long timescales	Extended timescales
Multilevel Organization	Misalignments in breath or pace are detected and become opportunities for careful adjustments.	They are able to develop abstract relationships to recurring patterns that support ongoing regulations.	Deviations might be reflected upon in a post-hoc fashion to produce adaptations over longer timespans.	Accumulated long-term disruptions (e.g. scheduling conflicts) drive transformative adaptations that persist beyond the conditions for which they emerged.
Incompleteness	Habits, no matter how short, are never perfect repetitions of previous forms, but are improvisations on a pattern.	Shifting environmental variabilities (e.g. shifting light) and bodily dynamics forces routines to remain open-ended.	They develop the capacity for open-ended exploration of new routes.	Long-term challenges (e.g. interpersonal tensions) necessitate continuous re-negotiation of commitments.
Criticality	Minor misalignments (e.g. breath or pace) are amplified to signal the need for correction, but not beyond what is reasonable (e.g. the pair needn't stop running).	Variability in environmental conditions destabilizes routines, prompting reorganization.	Running together necessitates the selective regulation of critical fluctuations at different scales, maintaining the general adaptivity of the system.	Continual attunement to what matters in the context of one's relationships allows for well regulated and well balanced integration across time and varying contexts.
Redundancy	Failure in one signal (e.g. a verbal cue) is compensated by overlapping channels (e.g. a visual cue).	Overlapping behavioral strategies buffer against disruptions, e.g. taking a new route.	Well developed repertoires allow for confident exploration beyond the places/ routes in which they have sedimented simpler habits.	Multiple channels counter systemic perturbations to maintain a functioning relational dynamic e.g. if one is overly stressed at work, the other might take up the burden of organizing their run.

The rows capture the enabling conditions, whereas the columns contain the timescales, from short to extended. Not all of the examples mentioned are drawn directly from the ethnographic material, but are likely to be recognised as relatively uncontroversial features of long-term relationships.

Short-timescales

At the shortest timescales, the emergence and reproduction of habitus rely on simple signals and actions that stabilize immediate coordination. 'Performative utterances', as described by Allen-Collinson and Hockey (2017), are a key 'mechanism' at this scale. These short, practical utterances or sounds – such as "On me!" or a grunt – convey immediate adjustments necessary to sustain the shared rhythm of running together. For example, Jacquelyn Allen-Collinson attuned to John Hockey's breathing patterns, detecting whether he was struggling and adjusting to her pace accordingly: "Jacquelyn would attend to his breathing patterns … picking up aural cues as to whether he was running with ease or struggling, and making continual adjustments to pace to ensure running together was maintained" (ibid, p. 184). Noise at this level is often subtle, such as mismatched breathing rhythms or slight misalignments in pace, which partners detect and respond to through habitual recovery actions – adjusting stride, speed, or position to restore alignment. Over time, these repeated adjustments become deeply ingrained habits, evolving into a shared, embodied repertoire that operates within the context of the interaction itself. As Allen-Collinson and Hockey emphasize: "These utterances refer to specific actions, at least for someone with insider knowledge of the particular utterance and what to do on hearing it" (ibid, p. 184).

In addition to verbal cues, non-verbal mechanisms such as the 'interrogatory glance' play a significant role. These momentary evaluations allow co-runners to check in on each other's state and make necessary adjustments to maintain the coordination of running together. As Allen-Collinson and Hockey describe: "The glance and the evaluation that occurred with it simultaneously constitute a process of habituated action" (ibid, p. 186). One variable closely monitored during these glances was the proximity of the running partner. Under typical conditions, a comfortable shoulder-to-shoulder distance was maintained. Deviations from this norm – such as one partner drifting ahead or falling behind – would animate a response from the other to restore alignment: "The normal pattern is only usually highlighted when it is breached … prompting one partner to ask the other if they were alright or to, by a process of trial and error, adjust the pace until tight running-together was again achieved" (ibid, p. 187). Here the role of noise is most evident in the notion of breaching. Recovery of the habitual coordination pattern is initiated contingent on emerging noise. This seems to imply that noise has a role in the reproduction of this habitus. But it also seems fair to assume that it had a role in its original enactment. In other words, the synchronous dynamics of running together that these shared habits help coordinate likely feel consonant, accompanied by a sense of co-optimal grip, whilst recurrent deviations from these dynamics will have provided some of the motivation for the emergence of these habits in the first instance.

Noise in these cases, and somewhat ironically, functions as a kind of diffuse signal, negated through habitual processes like interrogatory glances or verbal cues, enabling recalibration and recovery. Stochastic resonance may also be evident here, as the noise of altered breathing patterns or shifts in proximity makes weak signals more salient, prompting a faster and more precise adaptive response. The condition of *redundancy* also underpins these adjustments. For example, when a verbal utterance like "On me!" fails to elicit the desired response, the shared awareness of bodily movements, such as changes in breathing patterns, may provide an alternative pathway for recalibration. Similarly, if a glance to check proximity does not immediately resolve the noise, verbal cues or trial-and-error adjustments become additional mechanisms for recovery. The overlapping channels of communication ensure robustness, enabling the interaction to persist despite transient or partial breakdowns.

These habitual patterns emerge and are reproduced through situational recurrence and the possibilities made apparent through *multilevel organisation*. As certain verbal cues and glances prove valuable to the pair repeatedly navigating some set of shared affordances, they can inform the emergence of more enduring shared patterns and anticipations. The specific examples, such as Jacquelyn monitoring John's breathing, or their mutual adjustment of proximity, illustrate how micro-level disruptions are incorporated into a feedback loop that strengthens the more macro-level dynamic, e.g. the restorative utterance. Each instance of successful recalibration reinforces these norms, embedding them more deeply into the shared interactional repertoire. Finally, these short-timescale dynamics highlight the criticality of social interaction at this level. Noise does not overwhelm the system but is incorporated into its dynamics, balancing stability with flexibility. For instance, Jacquelyn's attention to John's breathing patterns reflects an ability to maintain coordination while responding adaptively to minor disruptions and scale them up as necessary. This balance ensures that the shared rhythm of running together remains coherent while remaining sensitive to the changing states of each partner.

By stabilizing coordination through micro-adjustments, these emergent patterns exemplify how noise serves as a generative force in the reproduction of short-timescale social habits. Performative utterances and interrogatory glances, as described by Allen-Collinson and Hockey, not only restore alignment but actively incorporate variability into the interaction, supporting a robust yet flexible dynamic. These short-timescale processes provide the foundation for the more complex patterns of coordination that unfold at longer timescales.

Medium-timescales

Another scale of patterning is reported as also relevant to the experience of running together. Borrowing from the sociological phenomenology of Alfred Schütz (1967), Allen-Collinson and Hockey (2017) adopt the notion of *typifications*, described as: "Common-sense constructs that were used to order the routine running life-world on a moment-to-moment basis, to organize and structure our experience … of training together" (p. 188). Elements in the above examples might already be understood as basic typifications, e.g., whereby one partner drifting off pace and losing proximity typifies that they are not "going well." As Allen-Collinson and Hockey write: "At the most immediate and sensory level there was a particular habituated action of seeing and hearing each other in a highly attentive way. These sensory perceptions themselves became categorized mutually by us, so that, in Schutz's (1967) terms, we typified each other" (2017, p. 188).

However, there is another "level of abstraction" that better captures this notion and recognizes patterning processes at work at longer timescales. Allen-Collinson and Hockey suggest that: "Built upon and interacting with these sensory perceptions [e.g. the interrogatory glance as a 'particular habituated action of seeing and hearing each other in a highly attentive way'] was a series of typifications at higher levels of abstraction, which encapsulated our mutual form over different kinds of terrain and in different climatic conditions" (p. 188). They report on several emergent patterns that were understood as such, e.g. either partner running in circles to let the other catch up when having either descended or ascended a hill; splitting and rejoining when encountering rough terrain because being too close might lead to bumps and bangs; each taking particular trajectories on familiar routes. These are all illustrative examples, but there is one example that is particularly instructive.

Jacquelyn, who has myopic vision, consistently chooses routes that provide the maximum available light, drawing from sources such as street lamps, shopfronts, and residential lighting. When running together in these conditions, the pair must frequently switch sides to adapt to shifting light levels along the route. Reflecting on this adjustment, they describe it as "so habitual in the dark months that it became almost prereflective (as if on 'automatic pilot') on well-traversed routes" (Allen-Collinson & Hockey, 2017, p. 181). This example illustrates how a complex adaptive routine can become deeply ingrained in a pair's habitual running dynamics, enabling them to remain responsive not only to each other but also to the broader set of environmental constraints shaping their movement.Through repeated exposure to similar conditions, they develop an intuitive sense of how best to sustain the norms of their ongoing coordination, gradually stabilizing a shared routine that allows them to navigate a challenging environment – and maintain a co-optimal grip –without continuous explicit co-regulation.

These dynamics highlight the role of noise as a generative force in the emergence of typifications. For example, the initial variability caused by Jacquelyn's need to adjust for lighting conditions introduced disruptions to the pair's coordination. These disruptions compelled a process of trial and error that eventually stabilized into the habitual practice of switching sides. Such noise, while initially disruptive, becomes essential for discovering and integrating new affordances into the shared interaction.

The condition of *incompleteness* is evident here, as the pair's responses are not predetermined or prespecified, but dynamically evolve through their mutual engagement with environmental and task constraints. Typifications emerge precisely because the pair's coordination remains open-ended, allowing them to adapt creatively to new conditions without rigidly adhering to predefined roles or patterns. Typifications also reflect the *criticality* of social interactions at these timescales. The practice of switching sides, for instance, represents a balance between stability and flexibility. This metastable state allows the pair to integrate variability – such as changes in lighting – without losing coherence in their overall interaction. The ability to adapt while maintaining stability is central to the generative potential of noise in the emergence of typifications. The redundancy inherent in these dynamics also ensures robustness in the face of disruptions. For example, when one partner fails to switch sides as expected, other layers of coordination, such as verbal cues or adjustments in pacing, provide alternative pathways for restoring alignment. This overlapping structure allows the interaction to remain resilient and adaptive, even when specific typified behaviors momentarily falter.

The emergence of typifications is closely tied to their reproduction through situational recurrence. Each time the pair navigates a familiar route or terrain, the norms embedded within the typifications are reinforced. The repeated practice of splitting and rejoining on rough terrain or switching sides in low light gradually embeds these patterns into the shared life-world of the runners. The example of switching sides in response to lighting conditions also underscores the role of noise in revealing new affordances. Initially disruptive, the variability introduced by uneven lighting conditions led to the discovery of an optimal strategy, which was then incorporated into the pair's habitual repertoire. This feedback loop illustrates how noise, far from being purely chaotic, serves as a critical driver of innovation and stability in social interactions, allowing for the emergence and stabilisation of habitual patterns that organise action over the course of seconds and tens of seconds.

Typifications also integrate short-timescale patterns, such as interrogatory glances or performative utterances, into more substantive schemes that organize behavior across broader temporal and environmental contexts. For instance, the glance used to assess proximity during a run may complement the broader typification of switching sides in response to lighting, demonstrating the nested nature of habitual dynamics across timescales within these interactions.

Long-timescales

At longer timescales, the dynamics of the interaction evolve into what might be understood as shared micro-identity, i.e. *running togther*. This is an emergent pattern of norms and shared meanings that structures recurrent interactions within particular situations. This organisation integrates the short and medium scale dynamics outlined earlier, but also acquires another degree of autonomous closure. Here the dynamic of running together can be seen as an emergent shared micro-identity with its own norms of self-production. This micro-identity reflects a metastable whole that enables the pair to adapt to shifting

environmental demands while maintaining certain variables within viability, e.g. sticking to the task of running together over different terrains and within varying degrees of tolerance. This shared identity allows the pair to adapt fluidly to novel challenges, while also motivating actions that reinforce the norms that guide their interaction within such situations.

Importantly, the stability and adaptability of these long-timescale dynamics are reinforced through recurrent interactions that ready the pair not only to interact with each other's bodies, but also with their environments and the affordances that exist therein. Allen-Collinson and Hockey emphasize the importance of this dynamic, writing that "[r]ecurrent interactions not only familiarize bodies with bodies, but also multiple bodies with places, such that the stabilities undergirding the experience of 'running together' are emergent from the whole complex" (2017, p. 178). And so, through repeatedly encountering and managing a whole variety of sources of noise, a general capacity to recover from breakdowns and manage stresses within the context of running together also emerges. This, in turn, can reinforce the inter-identity that as running partners they are, for instance, able to maintain their dynamic of running together even whilst they explore more unfamiliar terrains. The old adage is that a good test of a partnership is to go traveling together. Some research suggests that this might in fact be true (Shahvali et al., 2021), and that couples who can balance flexibility and cohesion during vacations are more likely to positively evaluate their relationships even outside of those contexts.

Long-timescale examples clearly illustrate the condition of multilevel organization, as the coordination between the pair operates across individual, interpersonal and community levels. Consider that the pair's behaviours are not only shaped by their immediate interaction, but also by broader patterns embedded in the environment, such as the roughness of the terrain, or the availability of light. Speaking of such complex attunements, Allen-Collinson and Hockey refer to Bäckström (2014) and the need to 'recognize the interrelatedness not just of mind and body, but also of mind, body, and place'" (2017, p. 178). And so, environmental regularities become intertwined with the intercorporeal dynamics of the pair, creating a mutually reinforcing system that sustains their shared micro-identity, which in turn may sustain certain environmental configurations, e.g. a path they take to avoid a wet patch becomes a desire path which recursively solicits their action on their next run. But these 'environments' are not merely material; they are also social – the path they lay down solicits not only their actions but those of other runners. As such, the emergent dynamics of running together reflect not only physical constraints but the norms, trends and fashions of the running subculture too. In effect, the interactional dynamics of running together are also shaped by and shape in return the broader cultural terrain in which they are embedded.

Noise at these long timescales continues to play a crucial role in the production and reproduction of social habits by producing dissonances that prompt recalibration or reinforce previous alignments in a multilevel way. For instance, a failure to adjust to an environmental constraint, such as uneven terrain, might lead the pair to bump into each other. Aware that such events might increase the risk of injury, and eager to continue running together throughout the season, the pair might put in place some strategies to avoid such missteps again, and enact and reinforce them any time they misstep again, or come close to it. Such strategies might emerge within the situation itself, as was true in the previous examples, but they might also emerge from more reflective interpersonal processes outside of the real time engagement, e.g. a conversation when they get back to the car in which they decide to compete at a lower level to minimise future threats. In such cases, noise may drive the need to shift their shared identity around what running together means for them.

The condition of redundancy is evident here, as multiple layers of coordination provide resilience against breakdowns resulting from noise, and allow for its generative potential to emerge. If one layer falters – such as the absence of familiar materials on a new route that is mostly sand – the pair can draw on verbal cues, environmental awareness, or their shared history of adaptation to restore and continue running together under these novel conditions. Through recurrent interactions across varying terrains, these dynamics become deeply embedded in the pair's shared life-world, forming the foundation for their habitus as running partners that disposes them to an open-ended exploration of affordances that might not be so available to, for instance, newly minted running partners, e.g. competitive trail runs they have never done before. At this level, performative utterances and typifications are incorporated into the broader shared micro-identity.

Extended-timescales

While Allen-Collinson and Hockey do not explicitly discuss the more extended timescale of interpersonal inter-identities, their work nevertheless provides some documented examples of stabilized patterns that organize relational activities at such timescales. We learn, for instance, that Jacquelyn Allen-Collinson and John Hockey are not only co-runners but also wife and husband. And so, for them marriage exemplifies a shared commitment that organizes their actions by providing a frame for coordinating their activities over extended periods. Their relationship is also structured around a two-year shared research project. Such commitments necessitate acting from compatible concerns that guide actions across extremely long timescales, relative to those spoken about previously. Of course, what exactly this means to these individuals in this relationship is something that will be emergent within the relationship as it evolves over time. Nevertheless, we can readily acknowledge these shared commitments both stabilize and are maintained by habits and habituated expectations within the relationship, and function as self-regulating organisations that orient the pair's actions relative to each other and their shared environments.

We often rely on cultural institutions to scaffold such extended relational dynamics. For Allen-Collinson and Hockey, the institutions of marriage, the subculture of distance running, and the field of sociology all provide orienting norms and conventions that shape their interactions, providing channels for them to improvise within, e.g. the institution of marriage legally binds the pair, making the coupling potentially more resilient to perturbations. As with the other scales, this process is not unidirectional. The pair's actions also feed back into these institutions, modifying them, even in small ways: their collaborative work on the sociology of running contributes to the academic institution of sociology; the ways in which they relate as husband and wife might inform others as to what is possible within such configurations, e.g. learning that they are indeed husband and wife, research collaborators and longtime running partners might broaden views of what is possible in a primary romantic relationship.

Noise also plays a generative role in the production and reproduction of patterns at these more extended timescales. For example, given the multilevel organisation of these dynamics, challenges encountered during their shared research project – such as scheduling conflicts or conceptual disagreements – likely led to strategies to mitigate those challenges or resolve the tensions that they produced, but moreover, also had value beyond the particular research project. The condition of incompleteness is also evident here, as the pair's shared routines and commitments are not rigidly pre-defined but dynamically emerge and evolve through recurrent interaction under general constraints, e.g. the shared goals of producing sociological insights. This openness allows them to adapt to novel challenges across a variety of domains that they are attempting to coordinate simultaneously. Having these multiple channels of coordination also likely introduces some redundancy into their relationship and allows for noise to play a generative role. If perhaps there is some tension in their marriage, but they are still able to go running together, or maintain a positive working dynamic, the general coherence and stability of the overall system might be well served, and might even provide opportunities to resolve the tensions outside of the dynamic in which they first surfaced, e.g. learning to better communicate in the context of working together may have value in their ability to communicate within their marriage.

Decomposed in this fashion, the dynamics of running together exemplify how shared lifewords are produced and propagated across multiple timescales. Immediate adjustments during runs feed into more complex typifications, which are in turn embedded within the longer term structures of situated micro-identities, which are themselves nested in extended inter-identities that rely on scaffolding from cultural institutions and more encompassing habitus. Each layer of habitual organisation is shaped by and shaping those they are both composed of and helping comprise. These recursive processes illustrate the mutual interdependence not only of the habitual dynamics at different scales within an interacting pair, but between individuals, their environments, and the sociocultural systems in which they are embedded.

Endogenous noise production and multiscale realignment

Noise in living systems is often treated as something exogenous, a disruption that comes from outside the system, or else as the result of internal error. In both cases, it is framed as something that interferes with the expected flow of dynamics. This view appears in some of the most well-known examples in

cognitive science. Francisco Varela's lost wallet story, for instance, involves an external mismatch between expectation and perception: he reaches into his pocket and finds his wallet missing, prompting a sudden shift in attention and behavior (Varela, 1999). Ashby's (1952, 1956) example of a kitten encountering fire makes a similar point: an external shock breaks the existing behavioural organisation and leads to adaptive reconfiguration (see also Froese & Stewart 2010). These are classic illustrations of systems reorganizing in response to external perturbations.

But not all noise comes from the outside. There are also forms of endogenously generated noise that seem to serve a similar adaptive function. Sighs, yawns, and pandiculations (spontaneous full-body stretches) can be understood as patterned disruptions that interrupt ongoing psychophysiological organisation and allow a shift to take place (Ramírez 2014; Severs et al., 2022; Vlemincx et al., 2022). Crying and laughing may also belong in this category. While this remains speculative, there is growing evidence that such gestures contribute to recalibration and multilevel/scale realignment. Sighs, for example, have been shown to restore respiratory variability and help reset affective and attentional states after periods of strain or stress (Vlemincx et al., 2013). Yawning is typically explained in individual terms, as a way of modulating arousal or regulating cortical temperature (Provine, 2012), but its contagiousness suggests a social dimension that has yet to be fully explored, but seems to be enabling of more coordinated social dynamics, e.g., when someone yawns around the campfire and it spreads among the group it plays a role in helping us transition from the warmth and comfort of the circle, to retire to our cold beds in anticipation of being up early. We propose that these gestures might act as noisy resets, internally generated perturbations that loosen entrenched states and support more situationally attuned coordination, not just at the level of the body, but potentially across multiple scales, including social interaction.

There is a related idea in recent work on decision-making and the role of intention in action. Mitchell (2023) argues that low-level neural noise is not simply random error, but can help a system break out of over-stable attractor states. Momentary variability enables the system to destabilize just enough to explore new trajectories or decide on one or another path forward. Froese (2023, 2024; see also Froese & Karelin 2023) takes this further. Rather than treating noise as a side effect of neural or physiological complexity, he suggests it can emerge from the dynamics of subjectivity itself. What he calls irruptions are moments when subjective effort introduces variability or disorder into an agent's ongoing bodily flows. Froese (2024, p. 2) describes this in terms of increased neural entropy, noting that "motivational efficacy introduces disorder into the … agent." This endogenous noise destabilizes entrenched patterns and creates openings for a kind of situational reset, where the relationship between intentions, habituated capacities, and present affordances can be renegotiated. These realignments are central to processes of adaptation, development, learning, creativity, insight, and change. The agent's role in this process, consistent with phenomenological accounts and the persistent challenge of the so-called intention–action gap, is not to impose control but to create the conditions through which more fitting and generative alignments can emerge.

Froese et al. (2024) also argue that irruptions play a key role in social interaction by disrupting synchronizations that tend to arise spontaneously due to our organisation as thermodynamically open systems. As they put it, "Desynchronization reflects a dynamic counterbalance to the integrative tendencies of synchrony. It is a means by which individuals assert autonomy and negotiate mutual alignment in social contexts" (2024, p. 14). Social interactions gravitate toward synchrony, the shared rhythms, mutual alignments, and coordinated patterns that arise through embodied coupling (see James and Loaiza 2020). Irruptions introduce moments of desynchronization that allow agents to modulate these dynamics in ways that preserve or restore individual autonomy. Consider the familiar experience of walking beside someone you do not know, perhaps after exiting an elevator. Without intending to, you begin to fall into sync in pace and stride. But because no explicit interaction has been initiated, the synchrony feels off. Breaking this rhythm requires a decision, perhaps to speed up or slow down, which introduces enough of a disruption to re-establish your own path. This small shift reflects subjective involvement in recovering autonomy by modulating interactional dynamics.

In interactions we do consent to, the same pull toward synchrony is usually present. We move in and out of alignment fluidly across multiple levels – neural, sensorimotor, affective, linguistic – and across multiple timescales, from microseconds to years. These dynamics of convergence and divergence, synchronization and desynchronization, integration and segregation, appear to serve the adaptive needs of both the participants and the interaction itself. As Froese et al. write, "Increased neural entropy disrupts inter-brain

synchrony, providing opportunities for agents to renegotiate the terms of interaction. This disordering is not a failure of coordination but a precondition for adaptive flexibility and creative reorganization" (2024, p. 8). Later they add, "Increased neural entropy acts as a countertendency to inter-brain synchrony, introducing variability necessary for flexible coordination. This variability is a hallmark of healthy, adaptive interaction" (*ibid*, p. 16). If this is right, it would make sense that living systems not only tolerate but actively generate such destabilising dynamics, and that these may be foundational to our capacities as agentive beings.

One potential lesson from this, with profound practical implications across nearly all domains of life, is that the fundamental role of noise in complex systems may lie in its support of multiscale realignment (see also Froese 2018). Noise allows agents within systems operating at multiple levels, from cells to societies, and across widely different timescales, from seconds to years, to better align and coordinate their actions relative to negotiated needs. Roli et al. approach a similar insight when they note that "noise increases the complexity of the system as a whole by augmenting the diversity of intra-system causal pathways" (Roli et al., 2024, p. 15). By complexity, they mean the number of processes within the system coordinating and communicating with each other. Increased diversity and effectiveness of these interactions could support the emergence of more symbiotic relationships among the various autonomous processes constituting a living system. In turn, this enhanced internal communication may enable systems to respond more flexibly and effectively to the stresses imposed by situational demands. Future research will explore how different regimes or types of strategically introduced noise (varying in source, scale, frequency, and intensity), combined with carefully designed and appropriately scaffolded environments, might foster regeneration or the emergence of new multiscale alignments better suited to satisfying our individual and collective needs. Given the ubiquity of noise and stress, it seems plausible that multiscale organisations, like life itself, would have capitalized on noise to facilitate targeted realignments.

Conclusion

This paper has explored the generative role of noise in the emergence and reproduction of social habits, reframing moments of desynchronization, error, and so on, as essential drivers of adaptive coordination across multiple levels and timescales. By integrating insights from embodied cognitive science, complexity theory, and autoethnographic sociological practice, we have argued that social habits are not rigid structures threatened by breakdowns, but dynamic multiscale alignments that support ongoing improvisation, continuously emerging through recursive cycles of disruption and recovery. Building on foundational accounts of social habits from Bourdieu, Merleau-Ponty, and Dewey – who emphasized how deeply individual habits are socially derived and how profoundly they structure action, perception, affect, and language – and incorporating recent insights from embodied cognitive science, which emphasize interactive social processes in the production and reproduction of social habits, we have extended this tradition by explicitly foregrounding noise as integral to habit formation.

As we have argued, even seemingly trivial disruptions, such as a broken microwave in a shared kitchen, can become powerful stabilizing forces, anchoring new alignments and structuring relational trajectories. From this perspective, noise is not simply something to avoid or minimize; it is potentially generative, something that might be actively cultivated and leveraged. By articulating the conditions under which noise can play a constructive role, we propose that social interactions provide an ideal context in which noise does not merely disrupt stability but generatively shapes the ongoing development of shared habitual patterns at various timescales.

These theoretical insights have significant practical implications when translated into actionable strategies for facilitating adaptation and change. One promising direction is through the framework of Wayshaping, an embodied, complexity-informed approach to behavior change and multiscale coordination (see James et al., 2025). Wayshaping explicitly recognizes noise as a valuable resource and deliberately integrates strategic 'shocks' into its practical interventions. In applied contexts such as education, therapeutic practice, and organizational settings, this approach can help design environments and interactions that strategically introduce scaffolds alongside appropriate forms of noise – varying in source, frequency, intensity, and timing – to facilitate shifts in habitual patterns, support skill acquisition, and stimulate creativity, innovation and learning.

Future research can take several empirical paths forward from here. Longitudinal observational studies, such as detailed cognitive ethnographies of how interactive repairs and realignments unfold over time, could help clarify the mechanisms through which noise supports adaptation in real-world contexts. Neurophenomenological inquiries into both the experiential and neurodynamic dimensions of these mechanisms would also be valuable. Recent advances in hyperscanning and two-person neuroscience make such investigations increasingly feasible, offering the possibility of tracking how noise interacts with scaffolding dynamics in shaping coordination, learning, and performance. Computational and dynamical systems modeling also present promising avenues, providing controlled environments in which hypotheses regarding criticality, multilevel organization, and so on, can be rigorously tested. For example, recent work has shown how systematic manipulations of noise and task constraints influence the emergence of synchrony, misalignment, and complementarity in dyadic interaction models (Miao, Dale & Galati, 2023). These insights also resonate with our own current use of analog models, including coupled pendulums and float tiles, to experimentally investigate how different types and timings of noise might support alignment and adaptive flexibility. One core issue for future work across all of these examples will be to explore the conditions under which noise ceases to be generative and becomes detrimental (e.g. leading to persistent breakdowns, emotional overload, trauma).

Important limitations regarding our proposed research perspective should be acknowledged. The generalizability of autoethnographic and phenomenological insights is necessarily constrained by their inherent contextual specificity, cultural situatedness, and interpretative character. These qualitative and phenomenological methods, though deeply informative, require complementary quantitative and experimental validation to refine and ground their claims more robustly.

Nevertheless, the present work sets the stage for precisely this kind of integrated, interdisciplinary research. By positioning noise at the heart of social habit formation and coordination dynamics, we shift the question away from how to eliminate or avoid disruptions, and instead ask how best to strategically work with, deploy and skillfully navigate noise. In doing so, we open new pathways for enriching education, enhancing therapeutic practice, fostering organizational flexibility and alignment, and deepening our understanding of the complex dynamics of social cohesion and cooperation. Rather than simply recoiling from noise, this paper, and the works that inspired it, invite us to engage with it intentionally and creatively, staying curious about its potential to facilitate the realignments essential for growth, learning, and meaningful change across our lives and relationships.

Notes

1. The interpretation of Allen-Collinson and Hockey's work through the lens of social habits was explored to some extent in James' (2021) PhD thesis. Some of the insights presented here were originally developed in that work but were not included in any subsequent publications. However, the detailed articulation of the role of noise in these processes is novel to this work. Interestingly, some earlier computer models also point to this possibility, e.g. Davies et al. (2011), and Bedia et al. (2019).
2. Generative roles for noise have been identified across a range of disciplines. In thermodynamics and systems theory, fluctuations are understood to drive self-organization in far-from-equilibrium conditions (Prigogine & Stengers, 1984). In evolutionary biology and innovation economics, randomness and disruption underpin adaptive transformation, from genetic mutation (Kauffman 1993) to processes of creative destruction (Schumpeter, 1942). In risk and complexity theory, Taleb (2012) argues that volatility and stress, under the right conditions, can enable antifragile growth. In neuroscience, Freeman (2000) proposes that neural noise supports perceptual reorganization, while Friston (2010) suggests that the brain's predictive models evolve through the minimization of error or surprise. Systems biology emphasizes the constructive role of stochastic variation in gene expression (Elowitz et al., 2002), and in machine learning, noise is routinely introduced to avoid overfitting and improve generalization (Srivastava et al., 2014). Our own lab has also begun using noise as a tool in models of self-optimization (Weber et al., 2022) that extend to basic forms of creative exploration (Weber et al., 2024).
3. Although we use the language of levels here, and at times what is 'lower' or 'higher' is less controversial, there is not necessarily a strict hierarchy to their organisation. Whether, for instance, some sensorimotor or linguistic dynamics constitutes a higher level in any particular instance of an interaction might be difficult to discern.
4. It may be that such cultural logics are, in some cases, traded off against a more stable or consolidated sense of cultural identity. The title of O'Toole's recent book, *We Don't Know Ourselves*, captures something of this tension. The phrase is richly polysemous in the Irish context. In everyday speech, it can signal joyful disorientation ("we don't know ourselves with the good weather"), but in O'Toole's usage, it also gestures toward a

deeper uncertainty about a long-standing difficulty in the Irish people settling into a coherent national or cultural identity. The phrase thus encapsulates both the adaptive ambiguity celebrated in the craic, and the historical dislocation that may underlie it.

Author contributions

CRediT: **Mark M. James**: Conceptualization, Writing – original draft, Writing – review & editing; **Chen Lam Loh**: Conceptualization, Writing – review & editing; **Georgii Karelin**: Writing – review & editing; **Natalya Weber**: Writing – review & editing; **Tom Froese**: Conceptualization, Writing – review & editing.

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Data availability statement

No data were generated in this work.

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