How to Coordinate Joint Actions

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0. Instructions

"Prospective authors should submit an abstract (120 words) plus a cover letter (two pages maximum) outlining what will be discussed in the article plus up to 20 key recent references (published in the past 2-4 years) via our online submission site (http://ees.elsevier.com/tics/)."

*NB: some of the sketch that follows is CUT&PASTE from the 'psychological research ...' paper or lightly re-written with no attempt to make it different (just shorter). I'm not sure to what extent these bits need to be re-written.

Abstract [139 words]

What enables two or more agents to coordinate their behaviours in order to achieve collectively ends that none could manage individually? Recent research on emergent coordination has shown how multiple kinds of perception-action coupling (such as entrainment and motor simulation) can, by making individuals act in similar ways, enable precise temporal coordination in joint action. Other research on co-representational coordination has investigated how representing another's task affects motor cognition, performance and perception in ways that can support predicting what others will do and where they will act. After reviewing recent cognitive and neuroscientific findings on each of emergent and co-representational coordination in turn we then assemble research on the synergy of these types of coordination in enabling effective joint action. Understanding significant cases of joint action requires understanding multiple types of coordination and how the mechanisms supporting them interact.

1. Introduction

Many of the significant events making up human lives are joint actions, as when we spontaneously hug, push a stranded car together or collectively celebrate a friend's wedding. Broadly conceived, joint action occurs when two or more agents' activities are coordinated and thereby effect or constitute some outcome. In many joint actions (imagine setting up a tent together), multiple types of coordination are required: the agents involved must share intentions and be similarly committed to the activity; they need meshing plans (concerning where to pitch the tent and how the task will be divided); they need broadly similar perspectives on their environment and what it affords them; and (with a large tent in bad weather) they will need to precisely coordinate some of their motor activities in space and time. What are the perceptual, cognitive, and motor processes that enable individuals to coordinate their actions with others? This article provides an overview of recent research that has either enhanced our understanding of joint action or raised new questions.

stephen butterfill 20/9/10 20:41

Comment: I would like us to update the (Sebanz, Bekkering, & Knoblich, 2006) working definition: it's ok as far as it goes but:

[1] it requires that joint actions should be 'social interactions' (which is a notion at least as hard to define as that of joint action)

[2] it specifies that 'two or more individuals coordinate their actions to ...': this is naturally understood as meaning that the individuals intentionally coordinate their actions (which is much too restrictive for the examples). The sentence I offer requires that the coordination matters for realising the outcome ('thereby') but not that anyone intends the coordination.

[3] it specifies 'in space and time'---while the cases we are interested in all involve space and time, we want to stress that there are cases where intellectual insight into other minds might be necessary and these include cases where there is no (or extremely little) need to coordinate in space and time (e.g. suppose that a facebook group collectively promotes a particular charity by agreeing to make it the sole benefactor of their wills; the joint action is that of promoting the charity.)

2. Types of coordination

We distinguish three broad types of coordination that can occur during joint action, intentional, co-representational and emergent coordination. In intentional coordination, agents not only intend to achieve a certain outcome but also intend to coordinate their plans and activities with each other, and they realise these intentions at least in part by reasoning or communicating about how best to act together. Coordination of this sort is due to what the agents intend and to their abilities to solve coordination problems by means of reasoning. Representations and processes postulated in theory of mind research such as common knowledge and mental state attribution are likely to be implicated in intentional coordination (Bratman, 2009).

s b 23/9/10 12:50

Comment: this is a subset of what we previously called 'planned coordination'; if we followed my suggestion of introducing 'intentional coordination' as a category we can't also use 'planned'.
. In the terms I'm tentatively proposing: 'planned coordination' contains 'co-representational coordination' and 'intentional coordination' (and possibly more)

s b 22/9/10 17:38

Comment: I've gone back to a three-fold distinction (as in Vesper et al): I'd prefer to take this approach because the alternative, "nuts and bolts" approach amounts to saying that we're not engaging with the philosophers here (which is fine in many cases, of course). On the other hand the distinction between intentional & co-representational coordination isn't yet sharp enough---it needs to be as clear & obvious as the distinction between co-representational and emergent coordination.

s b 23/9/10 12:21

Comment: Bratman, M. (2009). Modest Sociality and the Distinctiveness of Intention. *Philosophical Studies, 144*(1), 149-165.

In co-representational coordination agents' behaviour is driven by representations that specify the desired outcomes of joint action, the agent's own part in achieving these outcomes and (typically) another agent's part. How much is specified about another agent's part may vary. Co-representational coordination contrasts with intentional coordination to the extent that task representations drive coordination independently of any intentions or reasoning about coordination. Task representations may drive coordination by modulating motor cognition or perceptual processes, for instance; in such cases agents need not be aware that they are coordinating their actions. Put roughly, the contrast between intentional and co-representational coordination is the contrast between reflecting on how to coordinate two parts in an action and mentally performing both parts oneself.

s b 23/9/10 10:26

Comment: This might be stronger than you would like; it echoes Vesper et. al. where we said "people mentally perform the co-actor's task". Elsewhere you like to distinguish between

[1] co-representational effects, which might be explained in a variety of ways; and

[2] the hypothesis that co-representational effects are to be explained by

In emergent coordination, coordinated behaviour occurs due to perception-action couplings that make multiple individuals act in similar ways; it is independent of any joint plans or common knowledge (which may be altogether absent). Two separate agents may start to act as a single coordinated entity (Marsh et al., 2009; Spivey, 2007) because common processes in the individual agents are driven by the same cues and motor routines.

In what follows we consider research on emergent and co-representational coordination separately before turning to how these forms of coordination work together to enable effective joint action. While each form of coordination can be usefully investigated in isolation from the other, it is also essential to consider their synergy if we are to understand significant cases of joint action. We do not consider intentional coordination in the main review (*BOX to outline theoretical proposals; synergy) because there is almost no empirical research in this area.

3. Emergent Coordination

Emergent coordination takes various forms. Entrainment, the process of synchronizing two or more actors' rhythmic behaviours with respect to phase, is perhaps the best studied of theses form. For example, pedestrians often fall into the same walking patterns (Van Ulzen et al., 2008), and people engaged in conversation synchronize their body sway (Shockley, Santana, & Fowler, 2003). Entrainment can occur independently of (and even despite) agents' intentions (Schmidt & O' Brien, 1997) and without agents necessarily becoming aware of the entrainment (*ref).

stephen butterfill 23/9/10 12:14
Comment: is this right? I'm finding it hard to chase down a definition. Once source mentions "phase or periodicity" but I'm not sure what the difference is

How does entrainment support joint action? We do not suggest that entrainment always enables joint action, nor that all joint action involves entrainment (and this applies to emergent coordination generally). But entrainment does have multiple consequences for joint action. First and most directly, entrainment can facilitate precise temporal coordination, as required for example in putting on a marshal art display together (Schmidt, Fitzpatrick, Caron, & Mergeche, in press). In addition, entrainment can facilitate multi-limb coordination across individuals in ways resembling those found within an individual. Harrison & Richardson (2010) asked pairs of participant to walk around at a certain distance from one another able to see each other and connected by a big foam cube. In this condition they fell into a walking pattern that very much resembled a horse trot, suggesting that the same stable multi-limb coordination patterns can emerge within and across agents (cf. Mechsner & Knoblich, 2004). Less directly, entrainment of gaze between speaker and audience may facilitate understanding. Richardson and Dale (2005) recorded a speaker monologuing about six well-known characters while facing an array of uninformative silhouettes of the characters. The recording was then played back to subjects who were tested for comprehension. Degree of overlap between speaker's and hearer's gaze correlated with better comprehension, and this correlation persisted even when the degree of overlap was artificially manipulated by flashing

the pictures to control the hearer's gaze. This indicates that entrainment can support mutual understanding as well as facilitating precise temporal coordination.

*Perception action matching [suggest we elide other forms of emergent coordination].

4. Co-representational Coordination

Emergent coordination alone is not sufficient to explain joint actions where each agent must make predictions about what the others will do and which objects or locations their actions will be directed to (Schmidt, Fitzpatrick, Caron, & Mergeche, in press; Vesper, Butterfill, Knoblich, & Sebanz, in press). In prototypical cases of co-representational coordination agents represent an outcome to be achieved, their own task, and some aspects of other agents' tasks in achieving that outcome.

5. Synergy of Emergent, Co-Representational and Intentional Coordination

The three broad types of coordination we distinguished have complementary limits. Without emergent coordination it is arguably impossible to explain precise temporal coordination, particularly where this involves dynamical principles; but co-representation is needed for predicting how others will act and where their actions will be directed to in real time and intentional coordination is necessary where agents' long-term plans, not just their immediate activities, must be compatible and collectively adequate for achieving the joint outcome. Significant cases of joint action will therefore involve multiple types of coordination. How do the mechanisms which enable different types of coordination integrate with each other in enabling effective joint action? Unfortunately few have proposed detailed answers to this question and there is little direct evidence. However, many studies indicate

s b 23/9/10 12:06
Comment: Is this the right way to put the point?

that processes involved in co-representational and intentional coordination can tap into various mechanisms of emergent coordination recruiting the functionality of these fast and parallel mechanisms.

* ...

Entrainment appears to influence how much agents like each other (Hove and Risen 2009) and to boost people's willingness to cooperate. Wiltermuth & Heath (2009) showed that groups of participants who earlier engaged in synchronised walking or sang together persisted in making higher contributions in a public goods game than control groups.

6. Conclusion

BOX: Questions for future research

How do mechanisms of emergent and co-representational coordination work together or (in some cases) against each other? And what are the interfaces that allow these more basic processes of emergent and planned coordination to be integrated with the higher-level representations and processes such as common knowledge and mental state attribution characteristic of intentional coordination? [This is the general question; indented questions below are more specific]

s b 23/9/10 12:48

Comment: Shorter formulation (but I like the 'interfaces' idea so I didn't use it intially):

How do mechanisms of emergent, co-representational and intentional coordination work together or (in some cases) against each other?

Emergent coordination can occur irrespective of whether it promotes an agents goals (*ref); but in what ways (if any) can sharing intentions or task representations modulate mechanisms of entrainment, perception-action matching, and predictive action simulation?

Which perceptions need to be common to agents involved in a joint action in order for mechanisms of planned and emergent coordination to act in concert?

Does emergent coordination have a role in how joint action plans are set up and how roles are distributed between individual actors?

To what extent can shared task representations be modulated by explicit beliefs about the partner's task, or by beliefs about the partner's beliefs or intentions about one's own task?

Can variations in how successfully agents engage in emergent coordination (for instance, becoming behaviourally entrained or engaging in unconscious mimicry) serve as cues that indicate whether their desires or beliefs are incompatible?

What are the consequences of research on coordination among human agents for the design of robots that are built to engage in action with humans (e.g., Braun, Ortega, & Wolpert, 2009; Breazeal, 2002; Wachsmuth & Knoblich, 2008)?

So far there has been relatively little cognitive and neuropsychological research on phenomenological aspects of joint action. Are joint actions associated with characteristic phenomenology and, if so, how does the phenomenology interact with coordination mechanisms?

BOX: Intentional Coordination

s b 23/9/10 11:59

Comment: Rough notes on things that might go in boxes; since we can only have four and will want some boxes with details on experiments, we won't have room for all of these and might not have room for any.

While not directly concerned with mechanism, philosophical theories highlight a need for research on intentional coordination which is required for long-term planning ... One obstacle to progress is unexplained variety in accounts of shared intention ...

BOX: Team Reasoning

Bacharach, Sugden hi-lo games; theories about framing problems / switching modes of reasoning. Many psychological questions are not addressed by this literature: when team

rather than individual reasoning occurs, what its neurological markers are, synergy with other forms of coordination (Wiltermuth & Heath 2009); ...

[*delete/sharpen] BOX: Theoretical Divisions

*researchers divide between focus on representations and dynamical systems; in practice this distinct lines up with research on planned and emergent coordination. Associated with these research programmes are critiques of varying strength. [1] Vesper et. al. argue that dynamic approach can't explain novel goals and has limited applications to non-rhythmic behaviour; [2] (Schmidt, Fitzpatrick, Caron, & Mergeche, in press) argue that appeals to representation are metaphorical and need ultimately to be cashed out by more mechanisms; [3] (DeJaegher, DiPaolo, & Gallagher, in press) suggest that

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influenced by more abstract interpretative processes ... direct matching can be top-down modulated by the observer's interpretation of the observed movement as intended or not"]

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