Prosocial effects of coordination – What, how and why?

John Michael[a,*], Luke McEllin[a,b], Annalena Felber[c]

[a] Department of Cognitive Science, Central European University Budapest, Hungary
[b] Department of Psychology, University of Warwick, UK
[c] School of Communication and Culture, Aarhus University, Denmark

ABSTRACT

A wealth of research in recent decades has investigated the effects of various forms of coordination upon pro-social attitudes and behavior. To structure and constrain this research, we provide a framework within which to distinguish and interrelate different hypotheses about the psychological mechanisms underpinning various prosocial effects of various forms of coordination. To this end, we introduce a set of definitions and distinctions that can be used to tease apart various forms of prosociality and coordination. We then identify a range of psychological mechanisms that may underpin the effects of coordination upon prosociality. We show that different hypotheses about the underlying psychological mechanisms motivate different predictions about the effects of various forms of coordination in different circumstances.

1. Introduction

From marching in step to cooking meals, assembling furniture and forming political parties, coordination is a pervasive and important feature of human sociality. Indeed, we humans are uniquely able and motivated to coordinate our movements as well as our decisions, enabling us to achieve our goals more efficiently than we otherwise could, and in many cases to achieve goals that we could not achieve alone (Garrod & Pickering, 2009; Konvalinka, Vuust, Roepstorff, & Frith, 2010; Melis & Semmann, 2010; Silk, 2009; Skyrms, 2004; Tomasello, 2009).

In addition to these *direct* benefits of coordination, a wealth of research in recent years has provided evidence of potentially important *indirect* benefits arising from the effects of coordination upon prosocial attitudes and behavior. For example, it has been shown that coordination can enhance rapport (Bernieri, 1988) and trust (Launay, Dean, & Bailes, 2013; Mitkidis, McGraw, Roepstorff, & Wallot, 2015), and provide a boost to cooperation in social dilemmas (Guala & Mittone, 2010; Rusch & Luetge, 2016; Van Baaren, Holland, Kawakami, & Van Knippenberg, 2004; Wiltermuth & Heath, 2009) as well as helping behaviors (Kokal, Engel, Kirschner, & Keysers, 2011; Valdesolo & DeSteno, 2011), obedience (Wiltermuth, 2012) and commitment to

joint actions (Michael, Sebanz, & Knoblich, 2016a, 2016b). Moreover, the mere observation of interpersonal coordination creates a perception of rapport (Miles, Nind, & Macrae, 2009), unity (Lakens, 2010; Lakens & Stel, 2011), and the impression of a shared goal (Ip, Chiu, & Wan, 2006). There has even been researching indicating that the effects of coordination on prosociality emerge in early childhood (Barragan & Dweck, 2014; Cirelli, Einarson, & Trainor, 2014; Fawcett & Tunçgenç, 2017; Hamann, Warneken, & Tomasello, 2012).[1]

While this research continues to increase our knowledge of the effects of various forms of coordination upon prosocial attitudes and behavior, we have yet to develop a systematic understanding of the psychological mechanisms underpinning these effects (but see Cross, Turgeon, & Atherton, 2019 for a theoretical review paper summarizing and organizing much of this research). This makes it difficult to spell out testable predictions about many interesting cases in which coordination may or may not boost prosociality. What, for example, about cases in which two agents attempt to coordinate but do not succeed? In attempting to coordinate, they may signal to each other that they are interested in cooperating with each other; on the other hand, their failure may indicate to them that they are not well-suited to cooperate with each other. Similarly, what about instances in which two agents are mutually adapting to each other while performing very different

* Corresponding author at: Department of Philosophy, University of Warwick, CV4 7AL Coventry, UK.
E-mail address: Johnmichael.cogsci@gmail.com (J. Michael).

[1] It is worth noting that the effects of coordination extend beyond the prosocial attitudes and motivations that we are focusing on here. For example, there has been research investigating the effects of coordination on memory (Miles, Nind & Macrae 2009; Woolhouse & Lai, 2014; Woolhouse, Tidhar, & Cross, 2016), on joint action performance (Valdesolo, Ouyang, & DeSteno, 2010), on and perceptions of strength/formidability (Fessler & Holbrook, 2014; Fessler and Holbrook (2016).

actions (A blows into a trumpet while B plays the drums), or performing similar actions in a non-synchronized but nevertheless temporally coordinated pattern, for example in anti-phase synchronization (i.e. A taps her finger while B raises his, then vice versa, etc…)[2]? On the one hand, A and B are mutually adapting to each other to maintain a pattern, so one might expect them to develop positive attitudes towards each other – and indeed there is some evidence to support this (Cirelli et al., 2014; Miles et al., 2009). On the other hand, they are repeatedly performing different or even opposite actions, so one might expect them to not identify each other as good candidates for cooperation – and there is some evidence to support this as well (Wiltermuth, 2012). In borderline cases such as these, specific predictions should be motivated by background theory about how and why coordination boosts prosociality at all. And indeed, theoretical models of the psychological mechanisms mediating prosocial effects of coordination may also inform experimenters' decisions about which cases to treat as control conditions in experiments.

In the following, our aim will be to provide a framework within which to distinguish and interrelate different hypotheses about the psychological mechanisms underpinning various prosocial effects of various forms of coordination. We will begin by introducing a set of definitions and distinctions that can be used to tease apart various forms of prosociality and coordination (Section 2). We will then identify a range of possible psychological mechanisms (Section 3). As we shall see, different hypotheses about the underlying psychological mechanisms motivate different predictions about the effects of various forms of coordination in different circumstances (Section 4). Thus, a systematic overview of the theoretical landscape will provide structure and constraints to further empirical research.

2. Definitions and distinctions

In this section we will introduce some key definitions and distinctions. We begin by introducing a broad working definition of coordination, and then identifying factors which enable us to distinguish among a range of different forms that coordination can take. We then offer working definitions of prosocial behavior and attitudes.

2.1. Defining coordination

In defining coordination, we take what can be called a minimal approach (Butterfill & Apperly, 2013; Michael et al., 2016a, 2016b; Vesper, Butterfill, Knoblich, & Sebanz, 2010) – i.e., stipulating the minimum number of requirements to characterize the phenomenon of interest, and using this as a starting point from which to identify additional features that may serve as criteria for distinguishing among different forms of the phenomenon. With this in mind, we propose the following minimal definition of coordination: *An agent is coordinating with another agent to the extent that she adapts her actions or decisions to the actions or decisions of that other agent*, i.e. *to the extent that she acts or decides as she does at least in part because of the observed or expected actions or decisions of the other agent*. With this as our starting point, it will be possible to isolate the respective contributions of these different features to bringing about various prosocial effects on attitudes and/or behavior.

First, the minimal definition requires only that the actions or decisions of one agent be adapted to those of at least one other agent, not that both adapt to each other. In other words, coordination may be *unidirectional* or *bidirectional*. Some of the instances of coordination implemented in the research under discussion here are instances of bidirectional coordination (e.g. Konvalinka et al., 2010; Wiltermuth &

Heath, 2009). Other studies however implement unidirectional coordination, for example with a confederate assuming the role of 'follower' and coordinating her/his actions with those of a participant, who is in the role of 'leader' (Kokal et al., 2011; Sacheli, Tidoni, Pavone, Aglioti, & Candidi, 2013). Unidirectional scenarios make it possible to probe the effects of coordination independently of a participant's intention to coordinate. For instance, although the leader may or may not be acting with the intention to coordinate with the follower in unidirectional scenarios, the effects of coordination on the leader's prosocial attitudes towards the follower can still be probed.

Second, the minimal definition does not specify how the adaptation of actions or decisions is achieved. Typically, individuals are able to adapt *to each other* by perceiving each other's actions (e.g. when lifting an object together) or the effects of those actions (e.g. sounds produced by tapping or drumming). In other cases, the coordination may be directed *by an external agent or entity*, as when musicians in an orchestra are directed by a conductor. In experimental research, participants are sometimes instructed to adapt their actions to a rhythm indicated by an external cue (Cross, Wilson, & Golonka, 2016; Hove & Risen, 2009). In these cases, the participants may only coordinate with each other as a side effect of coordinating with the external cue. When this is the case, coordination may not provide a basis for drawing any inferences about one's partner's attitudes or about her or his willingness to adapt.

Third, the minimal definition does not require that there be a goal to the adaptation of actions or decisions.[3] With this point in mind, Knoblich, Butterfill, and Sebanz (2011) introduce a distinction between *emergent coordination* and *planned coordination*. In emergent coordination, actions or decisions are coordinated without a goal – i.e. there is no goal subserved by the coordination, nor is the coordination itself a goal. For instance, pedestrians often fall into the same walking patterns (Van Ulzen, Lamoth, Daffertshofer, Semin, & Beek, 2008) and people engaged in conversation synchronize their body sway (Shockley, Santana, & Fowler, 2003) and mimic one another's mannerisms (Chartrand & Bargh, 1999). In such cases, 'coordinated behavior 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). Rather, agents may process perceptual and motor cues in the same way as each other. E.g. mimicry, entrainment' (Knoblich et al., 2011: p. 62). In planned coordination, in contrast, two agents coordinate their actions or decisions in order to bring about a particular outcome that requires that they coordinate. In such cases, the outcome may be something over and above the coordination of actions or decisions (e.g., carrying a table out of the room), but the planned outcome may be coordination itself (such as when two agents are engaged in dancing). Here, the 'behavior is driven by representations specifying the goal of joint action and the individual contributions to the goal' (Knoblich et al., 2011: p. 62)[1]. This distinction matters because emergent coordination may provide less indication about one's partner's willingness to adapt to one's actions, as compared to planned coordination.

Fourth, the minimal definition specifies no criterion for *success* of coordination. There are many cases in which two agents attempt to adapt their behavior or decisions to each other (or when one of them does so unilaterally) in pursuance of a goal. The criteria for success will depend on the particular goal, which may be internal or external to the coordination. For example, when drumming together, the criterion for success may be reducing asynchronies below a particular threshold (i.e. a goal that is internal to the coordination). Or, when jointly moving a couch to another room, the criterion for success may be to achieve the

---

[2] This is in contrast to in-phase coordination (e.g. A taps her finger as B taps his, they both raise their fingers at the same time, then again tap them at the same time, etc).

[3] Indeed, the minimal definition does not by itself rule out cases in which agents are adapting to each other in pursuance of conflicting goals, e.g. in competitive sports. We put such cases to the side, as competition has not been a topic of interest in the context of research investigating the effects of coordination upon prosociality.

outcome that the couch be in the other room (i.e. a goal that is external to the coordination). And indeed, by manipulating coordination demands, experimentalists may influence the extent to which coordination is likely to be successful, and thereby disentangle any prosocial effects of the attempt to coordinate from the effects of coordination success. Kokal et al. (2011) for example used this method to implement a control condition in which coordination was unsuccessful, and observed significantly lower helping rates (their target prosociality measure) than in the test condition in which coordination was successful. On the other hand, one might interpret another agent's attempt to coordinate as a signal that she is willing to be accommodating and to invest effort in an interaction, which may make her into an attractive interaction partner. Finally, it is also worth highlighting a distinction between different (but not incompatible) forms of coordination: 'sensorimotor coordination' and 'decision-making coordination'. This distinction broadly corresponds to different ways in which coordination has been investigated in different domains of empirical research. Most of the psychological research investigating prosocial effects of coordination has focused on the former. i.e. the adaptation of actions between two agents. More specifically, much of this research has investigated what Cross, Wilson, and Golonka (2019) have termed 'coordinated rhythmic movement', which they define as 'a special class of coordination that involves aligning one's physical movements with another person's, in time to a common rhythm' (p. 248). In parallel to this, an independent strand of research has also begun investigating prosocial effects of coordinated decision-making in behavioral economics. In coordinated decision-making, agents adapt their decisions in light of what each other is likely to decide. Coordinated decision-making has been studied extensively within behavioral economics using coordination games (Cooper, DeJong, Forsythe, & Ross, 1990; Guala & Mittone, 2010; Rusch & Luetge, 2016; Schelling, 1960; Skyrms, 2004; Van Huyck, Battalio, & Beil, 1990). The key feature of coordination games is that both players receive higher payoffs if they choose the same option than if they do not. Everyday examples of coordinated decision-making include motorists choosing to drive on the right (or left) side of the road, and political parties forming strategic coalitions to enact their legislative agendas. Most research involving coordinated decision-making requires each agent to make a decision in light of what she expects the other agent to decide, and to do so in pursuance of the goal of achieving the best outcome (typically this means the best outcome for herself, although it can also be understood as the best outcome for both players or for some other agent(s)). In this sense, they involve planned coordination. This does not mean however that all decision-making coordination is planned. Trends in fashion, restaurants and music may be considered as cases of emergent decision-making coordination.

2.2. Prosociality

Prosociality is commonly defined as 'behaviors that are intended to benefit others' (Jensen, 2016; see also: Batson & Powell, 2003; Decety, Bartal, Uzefovsky, & Knafo-Noam, 2016; Eisenberg, 1982; Staub, 1978). However, as Jensen has recently pointed out, this definition of prosociality is not as straightforward as it may seem at first blush. In particular, it is important to highlight two complications, one methodological and one theoretical. First, consider the requirement that there be an *intention* to benefit others. The reason for this requirement is to exclude cases in which an agent brings a benefit to some other agent by accident or as a side effect of some other action. In practice, however, it may often be difficult to evaluate whether there is an intention, in particular in the case of pre-linguistic children or non-human animals (a point also noted by Eisenberg & Miller, 1987).

Secondly, the standard definition does not specify whether the aim of benefiting others must be the ultimate aim, or whether behaviors qualify as prosocial if they are performed in order to benefit others but with an ulterior motive. And indeed, some authors accept that

behaviors can be prosocial in spite of an ulterior motive (e.g. Decety et al., 2016). There are many different kinds of ulterior motive of course. Some ulterior motives may be morally neutral, such as aiming to maintain one's reputation (indirect reciprocity) or to motivate the recipient of the prosocial action to reciprocate in the future (direct reciprocity). Other ulterior motives may be decidedly antisocial. For example, the witch in Hansel and Gretel feeds the children (providing them a benefit) in order to fatten them up before eating them.

In view of these complications, we propose to work with a revised definition of prosocial behavior: *An action qualifies as prosocial if its performance is sensitive to the benefit to the other agent. More specifically, an action qualifies as prosocial if the agent would be less likely to perform that action if, other things being equal, it did not benefit the other agent.* This definition is in the spirit of the same minimal approach we have taken to defining coordination: it operationalizes prosociality in a manner that avoids the methodological difficulty of intention attribution, and which does not attempt to rule out cases in which an ulterior motive is also present. It does however rule out cases in which an agent brings about a benefit to another agent *solely* as a means of achieving some further aim.

Behavioral measures of prosociality often draw upon economic games developed within the tradition of game theory. These games make it possible to quantify (typically using monetary incentives) participants' prosociality – i.e. their willingness to make decisions which benefit others – under various circumstances (Camerer, 2011). The most famous of these is the prisoners' dilemma, which can be used to assess participants' willingness to cooperate when they could stand to gain more individually by defecting (Flood, Dresher, & Tucker, 2010; Nash, 1950). It is also quite common to implement public goods games, which have the same structure as prisoners' dilemmas but can include more than two players (Cross et al., 2016; Fischer, Callander, Reddish, & Bulbulia, 2013; Wiltermuth & Heath, 2009). Since cooperation in the prisoners' dilemmas and the public goods game depends upon participants' not only being prosocially inclined towards the other player(s) but also to trust them, dictator games (Güth, Schmittberger, & Schwarze, 1982) are sometimes preferred. By measuring how much of an initial endowment participants (in the role of the 'dictator' are willing to give freely to a recipient, dictator games are thought to provide a comparatively direct measure of prosocial motivation (Engel, 2011; Guala & Mittone, 2010). As a further alternative, the trust game devised by Berg, Dickhaut, and McCabe (1995) is often also implemented as a measure (Cross et al., 2016; Lang, Bahna, Shaver, Reddish, & Xygalatas, 2017). It is designed to measure participants' (i.e. the 'investor's') trust by probing their willingness to pass a sum of money to another participant (i.e. the 'trustee'), given that the sum that is transferred will be multiplied by some number (often 3), after which the trustee can choose to return any amount (including 0) to the investor. Some studies also implement scenarios in which a participant has an opportunity to help another agent perform some instrumental task, such as picking up something that an experimenter has dropped (Barragan & Dweck, 2014; Kokal et al., 2011; Valdesolo & DeSteno, 2011).

What about prosocial *attitudes*? It is worth highlighting a complication at this stage: since prosocial attitudes are not behaviors at all, they do not fall under the definition of prosociality we have given above. One possibility would be to characterize them as attitudes that dispose or motivate individuals to perform prosocial behavior. This would be problematic if the category of prosocial behaviors included cases in which an agent performs an action that benefits another agent but does so solely as a means of achieving some further aim. The reason why this would be problematic is that any attitude that motivates an agent to perform such an action would qualify as a prosocial attitude. This would include, for example, greed, which may motivate an agent to help someone cross the street with the further aim of picking their pocket. But we have ruled out such cases by restricting the category of prosocial behaviors to cases in which an agent is motivated at least in

part by the aim of bringing about a benefit to a recipient. We therefore stipulate that prosocial attitudes are those which motivate agents to perform actions that bring benefits to others *at least in part because* those actions bring those benefits.

To probe prosocial attitudes, participants are typically asked to fill out questionnaires assessing the degree of trust, closeness, connectedness and/or similarity they experience in relation to their partner (Cross et al., 2016; Wiltermuth & Heath, 2009). As a more implicit measure, participants are sometimes asked to indicate the amount of overlap they perceive between themselves and their partner using the *Inclusion of the Other in Self* (IOS) scale (Aron, Aron, & Smollan, 1992; Stupacher, Maes, Witte, & Wood, 2017). Typically, these are used as secondary measures in order to test hypotheses about the mechanisms underpinning the effects of coordination on prosocial behavior (Cross et al., 2016; Lang et al., 2017).

Typically, these prosocial behaviors or attitudes are directed towards the same agent as the participant previously coordinated with. Indeed, in some cases it has been shown that the prosocial effects do not extend to others (Wiltermuth, 2012), indicating that they are agent-specific. Some studies, however, have shown that the prosocial effects do extend to third parties who are affiliated with the coordination partner (Cirelli, Wan, & Trainor, 2016), or even to third parties who are not presented as being in any way affiliated with the coordination partner (Reddish, Bulbulia, & Fischer, 2014). This raises the question as to whether, when and why we should expect the prosocial effects of coordination to be agent-specific, or to generalize (e.g. to members of a particular group, or even to people in general)? Answers to this question are likely to differ according to one's background hypothesis about how and why coordination has such effects at all. We will return to this issue below.

3. Mechanisms

In this section, we introduce two orthogonal distinctions among types of hypothesized mechanism underpinning the effects of coordination on prosocial behavior and attitudes. The first distinction (Section 3.1) is among sources of motivation to engage in prosocial behavior which may be boosted by coordination: *concern for others' well-being*, *trust*, and a *sense of commitment*. The second (Section 3.2) is between two mechanisms by which coordination may lead one to identify some other agent as an appropriate target of prosocial behavior: via *group-identification* or by *agent-specific selection mechanisms*.

3.1. Mechanisms for generating prosocial motivation

The first distinction is among sources of motivation to engage in prosocial behavior which might be boosted by coordination: *concern for others' well-being*, *trust*, and a *sense of commitment*. The first of these – concern for others' well-being – is the most direct source of prosocial motivation. Indeed, we take it that to be motivated to perform an action out of concern for some other individual's well-being is to perform the action because it is in some other agent's interest. In this sense, it may be thought of as the prosocial core of prosociality (recall that our definition of prosociality requires that an agent perform an action at least in part because it benefits some other individual). Much of the research in this area can be interpreted as investigating the effects of coordination upon this source of prosocial motivation – e.g. using dictator games (Guala & Mittone, 201) or prisoners' dilemmas (Rusch & Luetge, 2016), or by implementing scenarios in which help is required (Barragan & Dweck, 2014; Kokal et al., 2011; Valdesolo & DeSteno, 2011).

However, concern for one's partner's well-being may not always be sufficient to drive prosocial behavior. This is because some prosocial acts (e.g. helping to move a heavy object) may be risky insofar as they require one to rely on others. They may, for example, expose one to the risk of being taken advantage of (while one is preoccupied with the heavy object, the other agent may pick one's pocket), or of wasting one's

efforts (e.g., if one's partner abandons the idea of moving the heavy object). For this reason, it is also important to consider the role of trust in supporting prosocial behavior – and indeed much of the research in this area does probe trust, either using trust/investment games (Cross et al., 2016; Wiltermuth & Heath, 2009) or by administering questionnaires (Cross et al., 2016; Reddish, Fischer, & Bulbulia, 2013).[4]

Recently, some research has highlighted a third, distinct source of motivation for prosocial behavior which may be boosted by coordination. Specifically, recent findings support the hypothesis that coordination may boost prosocial behavior by eliciting a sense of commitment to perform an action because one's partner is relying on one (Michael et al., 2016a). This is because, when two agents coordinate their contributions to a joint action, they form and implement interdependent, i.e. mutually contingent, action plans. For instance, when coordinating to move a pile of sand from a path agents may decide to form a chain, where one agent scoops up the sand and passes it to the other agent to be disposed of. The agents thus form interdependent action plans. Each agent must therefore have – and rely upon – expectations about what the other agent is going to do. Indeed, the higher the degree of coordination, the more spatiotemporally exact those expectations must be. One important consequence is that an agent's performance of her contribution within a highly coordinated joint action expresses her expectations about the other agent's upcoming actions, as well as her reliance upon those expectations. This may generate social pressure on the other agent to perform actions in order to avoid disappointing the expectations and wasting a partner's efforts.

3.2. Mechanisms for identifying recipients of prosociality

The second distinction we introduce is between two mechanisms by which coordination might lead us to identify another individual as an appropriate recipient of prosociality. Specifically, coordination may be thought to boost prosociality via *group identification* and/or via *agent-specific factors*. In other words, coordination may lead individuals to view each other as belonging to the same group, and to be prosocially disposed for this reason, or it may lead them to be prosocially disposed specifically to each other as individuals.

3.2.1. Group-level mechanisms

One prevalent idea in the literature is that coordination serves as an indicator that the individual with whom one is coordinating is similar to oneself and/or that s/he shares one's interests or goals, and that one therefore comes to view the other individual as part of one's social group (For a recent articulation of this view and review of the literature bearing upon it, see Cross, Turgeon, & Atherton, 2019). There are at least three ways in which coordination may indicate similarity between agents - at the level of behavior (i.e. doing the same thing at the same time), at the level goals (i.e. pursuing the same goals), and at the level of attentional focus (Tajfel, Billig, Bundy, & Flament, 1971) suggest that joint attention can lead individuals to perceive each other as members of a common group). However similarity is identified, the effects of coordination upon prosociality would then result from group identification. This *group-identification hypothesis* is motivated by research showing that people tend to exhibit favoritism towards ingroup members identified as such on the basis of cues as simple as wearing the same colors (Tajfel, 1970; Tunçgenç & Cohen, 2016; Turner, Brown, & Tajfel, 1979) or supporting the same sports team (Levine, Prosser, Evans, & Reicher, 2005).

The group-identification hypothesis is compatible with all three of the candidate mechanisms we distinguished at the motivational level. Identifying someone as an ingroup member may lead one to trust her more, since her interests qua ingroup member are likely to be relatively well aligned with one's own. Or, one may come to take an interest in

---

[4] For an overview of this research, see Cross, Turgeon, & Atherton, 2019.

their well-being irrespective of trust, and without any ulterior motive - one may develop genuine concern for the other agent's well-being. Thirdly, group-identification may elicit a sense of commitment to the partner qua group member. This is because shared membership in a group may raise the expectation that one will act in another agent's interest (Michael et al., 2016a, 2016b).

3.2.2. Agent-specific mechanisms

A distinct possibility is that coordination may boost prosociality by providing information about the specific individual with whom one is coordinating. For example, if coordination is successful, it may serve as a cue to the other individual's competence at a particular task or in general - evolutionarily, it may indeed have been important to choose competent partners for important endeavors (e.g. for hunting or patrolling). In addition to information about others' competence, coordination may also serve as an indication of a partner's relevant dispositions. In particular, coordination indicates that a partner is willing to adapt her behavior, and to pay attention to one's own actions in order to facilitate adaptation. This might be deliberate – e.g., by holding the door open for someone, you indicate that you are paying attention to her and willing to adapt your behavior to facilitate her goal of getting through the doorway. But in many cases it is a side effect – e.g. if the driver of a car indicates that she will turn left, you might slow down to avoid a crash. In this case you are not slowing down with the aim of indicating to the other driver that you are willing to adapt to her in order to facilitate coordination, but she might nonetheless recognize this. If, in cases like this, I recognize that some other agent is willing to adapt to me, it may elicit prosocial behavior in future interactions with this agent. This is because her willingness to adapt is a form of effort investment, and the perception that another agent is investing effort to facilitate my own goals can elicit prosocial behaviors and attitudes (Chennells & Michael, 2018; Green, McEllin, & Michael, 2019; Székely & Michael, 2018).

As with the group-identification hypothesis, all three candidate mechanisms at the motivational level are consistent with the hypothesis that the perception of a partner's effortful investment to coordination may boost prosocial attitudes or behavior towards that specific partner: trust, concern for the partner's well-being and a sense of commitment. Let us consider each in turn.

First, the perception of a partner's effort investment may give rise to a concern for her well-being. This is because effort investment may be an indication of the other agent's care for you, or it may indicate that this agent is a friend or close collaborator. In these ways, perception of a partner's effort investment may lead one to value and/or respect her, and to like her personally as a result of this.

A second possibility about how coordination boosts prosociality is that the other agent's willingness to pay attention and adapt may provide evidence that she will also be willing to do this in future interactions, thereby providing grounds for trusting her. If so, it could be in my interest to maintain a good relationship with her with a view to future interactions. This would be a case of direct reciprocity. It is also consistent with the interdependence hypothesis, insofar as the other agent's willingness to adapt may indicate that her interests are aligned with mine, and that it is therefore in my own interest to support her.

A third possibility is that coordination may give rise to a sense of commitment to one's interaction partner. In support of this, Michael et al. (2016a) reported evidence that the degree of coordination in a joint action also enhances observers' perception of the agents' commitment to the joint action. Building on this, Székely and Michael (2018) (cf. also Chennells & Michael, 2018) found that the motivation to remain engaged in a boring joint action, and to resist tempting alternative options and distractions, is governed in part by an implicit sense of commitment which is modulated by the amount of effort that one's partner has invested in the joint action. That is, recognition of the other agent's willingness to coordinate (indicated by her investment of effort in the joint task) boosts prosocial behavior (operationalised as

persistence with the boring joint task) by fostering a sense of commitment to the other agent. The commitment hypothesis is consistent with direct or indirect reciprocity, and also with the interdependence hypothesis.

4. Linking theory to predictions

In the previous section, we introduced two orthogonal distinctions. The first distinction was drawn among types of motivation underpinning the prosocial attitudes and/or behavior: we distinguished trust, concern for others' well-being, and the sense of commitment. The second distinction referred to the target of prosocial behavior: it was drawn between mechanisms whereby coordination boosts prosocial attitudes and/or behavior via group identification and mechanisms whereby it does so in an agent-specific manner, i.e. without group identification. In this section, we offer some suggestions for disentangling the different hypothesized factors picked out by these distinctions. We begin with the distinction between group-level and agent-specific mechanisms.

4.1. Group-level or agent-specific mechanisms?

What specific predictions might differentiate between group-identification and agent-specific mechanisms as hypotheses underpinning the effects of coordination on prosociality? The key difference which provides a useful starting point for identifying contrasting predictions is that the group-identification hypothesis is based upon the idea that coordination acts as a cue to similarity, whereas the agent-specific hypothesis is based upon the idea that a partner's willingness to adapt can trigger prosocial attitudes and behavior. In spelling out these predictions, it will be important to recall, as noted above, that there are at least three levels at which coordination may provide a cue to similarity, and thus to shared group membership: namely, at the level of behaviors, at the level of goals, or at the level of attentional focus. We will proceed by considering characteristic features, or parameters, of situations involving coordination (as identified above, in Section 2.1) and asking whether the contrasting hypotheses generate different predictions about these parameters.

4.1.1. Unidirectional versus bidirectional coordination

The group identification hypothesis and the agent-specific hypothesis lead to different predictions in cases of unidirectional coordination. In particular, we should only predict that the direction of unidirectional coordination matters for agent-specific hypotheses. Assuming that A is following B's lead, agent-specific hypotheses predict higher prosociality from B towards A because the coordination signals A's willingness to adapt to B. In contrast, either direction of uni-directional coordination signals similarity between A and B, so the group identification hypothesis does not predict that the direction of coordination makes a difference with respect to subsequent prosociality.

4.1.2. Successful versus unsuccessful coordination

Insofar as the group identification hypothesis assumes that group-identification is triggered by the perception of self-other similarity at the level of behavior, we suggest that it does not predict a boost to prosociality through unsuccessful coordination. In contrast, versions of this hypothesis which assume that group-identification is triggered by the perception of similarity at the level of goals or attentional focus should indeed predict that unsuccessful coordination will provide a boost to prosociality. This is because the mere attempt to coordinate and/or to engage in joint attention may signal that one is a group-member (by signaling that agents share the same goals/interests). The agent-specific hypothesis also predicts that coordination should provide a boost to prosociality irrespective of how successful it is, because even unsuccessful coordination provides evidence that one's partner is *willing* to adapt - it's the thought that counts. And indeed, this is consistent

with existing findings (Cross et al., 2016; Kirschner & Ilari, 2014; Launay et al., 2013).

4.1.3. Emergent versus planned coordination

Next, the group-identification hypothesis does not appear to provide us with a reason to predict differences between emergent and planned coordination. This is because it implies that similarity (whether of behavior, goals or attentional focus) itself triggers prosociality, irrespective of whether the similarity is brought about intentionally (though we may expect planned coordination to provide a stronger or a more salient cue to similarity). The agent-specific hypothesis, in contrast, does predict a distinction between the effects of emergent and planned coordination on prosociality. Specifically, it leads us to expect increased prosociality following planned coordination as compared to emergent coordination, as only planned coordination indicates that one's partner is willing to deliberately adapt her behavior to facilitate one's actions or goals.

In one study bearing upon this issue, participants observed agents walking synchronously or asynchronously and were asked to rate the level of rapport they perceived between the agents (Lakens & Stel, 2011). Crucially, participants viewing the synchronous walkers were either told that the two agents had been instructed to walk in synchrony or that they had spontaneously fallen into synchrony. The key finding was only participants who believed that the two agents had spontaneously synchronized with each other perceived them to have greater rapport than the asynchronous walkers. This suggests that synchrony leads to the appearance of rapport not because of similarity at the level of behavior but because of what it leads observers to infer about agents' attitudes towards each other. It is important to note, however, that these findings do not enable us to draw firm conclusions about whether participants' inferences concerning rapport were mediated by the attribution of an intention to synchronize. A follow-up to the original study by Lakens and Stel could investigate whether the relationship between rapport and synchrony when actors are not instructed to synchronize depends on whether they have intentionally decided to synchronize (planned coordination) or unintentionally fallen into synchrony (emergent coordination).

4.1.4. In-phase versus anti-phase coordination

What about the difference between in-phase coordination (e.g. A taps her finger as B taps his, they both raise their fingers at the same time, then again tap them at the same time, etc) and anti-phase coordination (e.g. A taps her finger while B raises his, then vice versa, etc…)? Anti-phase coordination is an interesting test case insofar it requires two agents to mutually adapt to each other while performing very different, even opposite, actions. As such, it is paradigmatic for a broad range of cases in which two agents adapt to each other while performing different actions (A blows into a trumpet while B plays the drums), or performing similar actions in a non-synchronized but nevertheless temporally coordinated pattern.

Here, again, different versions of the group identification hypothesis diverge according to the level at which they assume that the perception of similarity is relevant. Hypotheses which assume that group-identification is triggered by the perception of self-other similarity at the level of *behavior* lead us to expect a boost to prosociality from in-phase synchronization, but not from anti-phase synchronization, since in the latter case the two agents' actions are diametrically opposed. This prediction is consistent with the results of Wiltermuth and Heath (2009), where anti-phase synchronization was implemented as a control condition. In contrast, hypotheses which assume that group-identification is triggered by the perception of similarity at the level of goals predict that anti-phase synchronization should boost prosociality to the same extent as in-phase synchronization, since in both cases the two agents are contributing to the maintenance of a single pattern. Similarly, agent-specific hypotheses do not lead us to expect a difference between in-phase and anti-phase coordination, because these both

involve adapting to one's partner's behavior. This prediction is consistent with the results of Miles et al. (2009) and of Cross et al. (2016, Exp. 2), which indicated a boost to rapport following anti-phase synchronization.

4.1.5. Further points of comparison

In addition to the aforementioned parameters of situations involving coordination, there are a range of further points of contrast between agent-specific hypotheses and group-identification hypotheses. One such point of contrast is the question as to whether we should expect prosocial behaviors and attitudes following coordination to be directed specifically towards one's coordination partner, towards groups of agents, or towards others in general. The agent-specific hypothesis clearly predicts the former. In contrast, the group-identification hypothesis may predict that such prosocial effects of coordination extend to other members of the same group – i.e. if coordination leads A to identify B as an ingroup member, then we may expect A to be prosocially motivated not only towards B but towards other individuals perceived as belonging to the same group as B. The available findings in the literature present a complex picture, making it difficult to evaluate these predictions. Consistent with the agent-specific hypothesis, some studies have revealed prosocial effects of coordination which do not extend to anyone other than the person with whom participants coordinated (Cross, Wilson, & Golonka, 2019; Kokal et al., 2011). The prediction of the group-identification hypothesis also enjoys some support from a recent study showing a reduction in Hungarian participants' negative attitudes towards Roma individuals in general after synchronized walking with a Roma participant (Atherton, Sebanz, & Cross, 2019). Moreover, in the developmental literature, Cirelli et al. (2016) found that infants who had been bounced in synchrony with an adult were more likely to help not only that same adult (compared to a condition in which they had been bounced out of synchrony with the adult) but also a third party with whom that adult had affiliated. In contrast to these findings, Reddish et al. (2014) did find that coordinated movement boosted participants' willingness to share resources with others who had been involved in a different task. Further research is needed in order to pinpoint the factors which may influence any generalization of the prosocial effects of coordination beyond the specific coordination partner.

A related point is that the group identification hypothesis, unlike the agent-specific hypothesis, implies that the effects of coordination are mediated by the same mechanism as other prosocial effects of group identification. If this is correct, then we might expect coordination not to have any effect on prosociality in a context in which the other individual is already perceived as an ingroup member. And indeed, this is precisely what Cross, Turgeon, and Atherton (2019) found. A related prediction is that if coordination boosts prosociality by means of group-identification, then we may expect such effects of coordination to be blocked by cues indicating that the other agent is not in one's ingroup.

Finally, a further point of contrast is that group-identification mechanisms might be more basic, and thus developmentally prior to, agent-specific hypotheses. This conjecture is motivated by the observation that the former requires only that an agent notice a similarity between herself and another agent. The latter, in contrast, involves not only noticing what the other agent is doing, but drawing inferences about the motivation underlying this behavior – that the other agent is acting as they are because they are attempting to adapt to one's own behavior. That is, group-identification hypotheses may be less cognitively demanding than agent-specific hypotheses (insofar as they do not require inferences about underlying motivations). In support of this prediction, we know that infants can identify similarities and dissimilarities between themselves and others from the first year of life (Garcia Coll, Garcia Miranda, Buzzetta Torres, & Nogueras Bermúdez, 2018; Pun, Ferera, Diesendruck, Kiley Hamlin, & Baron, 2018; Xiao et al., 2018), and that prosocial helping behavior in infants and young children is boosted by synchronization (Cirelli et al., 2014; Cirelli et al.,

2016) and other forms of coordination (Barragan & Dweck, 2014).

4.2. Trust, concern for others' well-being or a sense of commitment?

A useful starting point in distinguishing among these hypothesized mechanisms is the observation that trust helps only indirectly to sustain agents' motivation to act cooperatively – i.e., it stabilizes one agent's expectation that her partner will continue acting in a cooperative manner, and thereby reduces a source of uncertainty which could undermine the first agent's motivation to act cooperatively. But it does not directly explain why that first agent would then herself want to act in a cooperative manner.

To illustrate, consider one study investigating effects of decision-making coordination upon subsequent cooperation. Rusch and Luetge (2016) reasoned that humans may be equipped with social decision-making processes which do 'not differentiate between instances of coordination and cooperation too sharply, at least initially, reflecting the hypothesized predominance and earlier evolutionary solution of coordination problems in our ancestral social ecology' (Rusch & Luetge, 2016: 292). If so, then successful coordination with a partner in a repeated coordination game may lead people to view their partner as being a reliable partner in general, and therefore also as someone who is likely to resist temptations to behave selfishly (e.g. to cooperate in a prisoners' dilemma). As a result, they themselves should be more likely to cooperate with a partner with whom they share a history of successful coordination. Rusch and Luetge (2016) found evidence of a 'spillover effect' from coordination to cooperation, i.e. cooperation rates in a prisoners' dilemma were boosted when rounds of the prisoners' dilemma were interspersed among rounds of a coordination game (i.e. the stag hunt) played together with a fixed partner.

But while Rusch & Luetge's hypothesis explains why successful coordination may lead participants to trust that their partner will not defect, this does not directly explain why they themselves would then choose to cooperate. As a result, it can only explain why cooperation rates would not fall below the level corresponding to what participants prefer; it does not provide any explanation of why coordination may directly boost cooperation rates. To explain this, we would need to identify a mechanism that accounts for a boost in prosociality – such as a genuine concern for one's partner's well-being, or a sense of commitment to the partner. In other words, cooperation in a standard prisoners' dilemma depends not only on participants' trust that their partner will cooperate but also on a motivation to cooperate. In Rusch & Luetge's study, it is therefore difficult to determine whether successful coordination boosted cooperation rates by affecting trust, concern for the partner, the sense of commitment, or some combination of these.

How could one isolate any effects of coordination upon trust? Trust/investment games may seem at first blush to be well-suited to this purpose, but may also confound these factors, insofar as an investor may contribute in part out of generosity or out of a sense of commitment – i.e. to ensure that the trustee receives a good outcome. In order to address this, one possibility would be to design a trust game in which an investor's decision does not affect the outcome for the trustee.

One way to isolate the motivation to bring about a benefit to one's partner – i.e. to specifically assess the effects of coordination upon a concern for a partner's well-being or upon the sense of commitment independently of trust – is to implement a *one-sided* social dilemma, such as a dictator game, in which only one player is faced with a temptation to defect. Since the decision of the dictator in a dictator game fully determines the outcome, she does not need to trust in the good will of her partner. This is the strategy adopted a study by Guala and Mittone (2010), which found evidence of a boost to prosociality in a dictator game following decision-making coordination. It must be noted, however, that this method does not distinguish between prosociality motivated by concern for the recipient and prosociality motivated by a sense of commitment to one's partner.

But how to tease apart concern for a partner's well-being and a sense

of commitment to one's partner? We identify three possibilities. One would be to manipulate the amount of effort or other costs (including opportunity costs) which participants believe their partners have had to invest in order to sustain coordination. As noted above, it has been shown (Chennells & Michael, 2018; Székely & Michael, 2018) that the motivation to remain engaged in a boring joint action, and to resist tempting alternative options and distractions, is governed in part by an implicit sense of commitment, which is modulated by the amount of effort that one's partner has invested in the joint action. Building upon this idea, Mills, Harry, Stevens, Knoblich, and Keller (2018) found that participants' belief that their partner was adapting to them deliberately led to improved performance on a synchronization task. They suggest that this may have been because participants felt a sense of commitment to reciprocate the effort they believed their partner was investing. It must be noted that an increase in prosociality following upon a partner's investment of effort or other costs in a coordinated activity may be explained not only by appeal to a sense of commitment to the partner but also by appeal to a concern for the partner's well-being. However, a sense of commitment, unlike a concern for the partner's well-being, should be sensitive to the extent to which one believes that the partner's investment of effort or other costs was made on the basis of an expectation about how one would reciprocate.

A second possibility would be to investigate the degree to which an agent is willing to help her partner achieve a goal that is *bad* for the partner in the long-run, but which the partner nevertheless wants. An example of this sort of prosociality might be, say, purchasing cigarettes for a friend when you are in a country where cigarettes are relatively cheap - it is certainly bad for your friend, but it is still prosocial insofar as you are doing your friend a favour (they want the cigarettes). In this case, one may be acting out of a sense of commitment to one's partner but not necessarily out of a concern for her well-being.

A third possibility arises from the observation that agents can not only be committed to *each other* but also to *goals themselves*. This is something that cannot be said of trust or concern for another agent's well-being - these are inherently tied to other agents, whereas one can be committed to bringing about a particular outcome independently of other agents. Importantly, agents sometimes find themselves committed to others' goals in virtue of being committed to the other agent. For instance, in committing myself to help another agent with a particular goal, I may take on that agent's goal as my own. If the other agent abandons that goal, I may then continue to pursue it anyway. Different versions of this basic idea have been referred to as *goal contagion* (e.g. see Aarts, Gollwitzer, & Hassin, 2004; Dik & Aarts, 2007; Jia, Tong, & Lee, 2014; Loersch, Aarts, Keith Payne, & Jefferis, 2008; Pontus & Shah, 2013), or *goal slippage* (Michael & Székely, 2017). Goal contagion or goal slippage might result from, or be enhanced by, the perception of a joint action partner's effort investment, insofar as effort investment may elicit a sense of commitment to one's partner (and consequently to one's partner's goals). Suppose that agents A and B coordinate in such a manner that B invests considerable effort (thereby eliciting a sense of commitment on the part of A). Agent A may then feel committed to helping B with her goals. If B were to abandon her goal, A's sense of commitment may lead her to complete B's abandoned goal anyway.

5. Conclusion

We have attempted to provide structure and constraints, as well as fresh insight, to the burgeoning research investigating prosocial effects of coordination. First, we have proposed working definitions of coordination and of prosocial behavior and attitudes, and identified a range of typical features of coordination which may be important in mediating between coordination and prosociality. We have also introduced a pair of distinctions among mechanisms by which coordination may boost prosociality, and made several suggestions as to how these mechanisms could be teased apart empirically. We hope that this conceptual groundwork will provide structure and direction for

future empirical research testing the hypotheses spelled out here, and also for theoretical work developing mathematical formalizations of the concepts and the hypotheses we have articulated.

Needless to say, our attempt to tease apart various distinct hypotheses about mechanisms does not imply that only one of them is correct, or that any one of them should be able to explain all instances in which coordination provides a boost to prosociality. Rather, different mechanisms may be at work in different contexts, and in some contexts they may also act in concert. This opens up new directions for future research investigating the relationship among different mechanisms mediating between coordination and prosociality.

Declaration of competing interest

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

Acknowledgements

Funding

References

Aarts, H., Gollwitzer, P., & Hassin, R. (2004). Goal contagion: Perceiving is for pursuing. *Journal of Personality and Social Psychology, 87*(1), 23–37.

Aron, A., Aron, E. N., & Smollan, D. (1992). Inclusion of other in the self scale and the structure of interpersonal closeness. *Journal of Personality and Social Psychology, 63*(4), 596–612.

Atherton, G., Sebanz, N., & Cross, L. (2019). Imagine all the synchrony: The effects of actual and imagined synchronous walking on attitudes towards marginalised groups. *PLoS One, 14*(5), e0216585.

Barragan, R. C., & Dweck, C. S. (2014). Rethinking natural altruism: Simple reciprocal interactions trigger children's benevolence. *Proceedings of the National Academy of Sciences, 111*(48), 17071–17074.

Batson, C., & Powell, A. (2003). Altruism and prosocial behavior. In T. Millon, M. Lerner, & I. Weiner (Eds.). *Handbook of psychology: Vol. 5, Personality and social psychology.* New Jersey: John Wiley & Sons, Inc.

Berg, J., Dickhaut, J., & McCabe, K. (1995). Trust, reciprocity, and social history. *Games and Economic Behavior, 10*(1), 122–142.

Bernieri, F. J. (1988). Coordinated movement and rapport in teacher-student interactions. *Journal of Nonverbal Behavior, 12*(2), 120–138.

Butterfill, S. A., & Apperly, I. A. (2013). How to construct a minimal theory of mind. *Mind & Language, 28*(5), 606–637.

Camerer, C. F. (2011). *Behavioral game theory: Experiments in strategic interaction.* Princeton University Press.

Chartrand, T. L., & Bargh, J. A. (1999). The chameleon effect: The perception–behavior link and social interaction. *Journal of Personality and Social Psychology, 76*(6), 893–910.

Chennells, M., & Michael, J. (2018). Effort and performance in a cooperative activity are boosted by perception of a partner's effort. *Scientific Reports, 8*.

Cirelli, L. K., Einarson, K. M., & Trainor, L. J. (2014). Interpersonal synchrony increases prosocial behavior in infants. *Developmental Science, 17*(6), 1003–1011.

Cirelli, L. K., Wan, S. J., & Trainor, L. J. (2016). Social effects of movement synchrony: Increased infant helpfulness only transfers to affiliates of synchronously moving partners. *Infancy, 21*(6), 807–821.

Cooper, R. W., DeJong, D. V., Forsythe, R., & Ross, T. W. (1990). Selection criteria in coordination games: Some experimental results. *The American Economic Review, 80*(1), 218–233.

Cross, L., Turgeon, M., & Atherton, G. (2019). How moving together binds us together: The social consequences of interpersonal entrainment and group processes. *Open Psychology, 1*(1), 273–302.

Cross, L., Wilson, A. D., & Golonka, S. (2016). How moving together brings us together: When coordinated rhythmic movement affects cooperation. *Frontiers in Psychology, 7*, 1983.

Cross, L., Wilson, A. D., & Golonka, S. (2019). I'll just watch: Do the pro-social effects of

coordination really generalize to non-actors? *The Journal of Social Psychology,* 1–15.

Decety, J., Bartal, I. B. A., Uzefovsky, F., & Knafo-Noam, A. (2016). Empathy as a driver of prosocial behaviour: highly conserved neurobehavioural mechanisms across species. *Philosophical Transactions of the Royal Society B: Biological Sciences, 371*(1686), 20150077.

Dik, G., & Aarts, H. (2007). Behavioral cues to others' motivation and goal pursuits: The perception of effort facilitates goal inference and contagion. *Journal of Experimental Social Psychology, 43*(5), 727–737. https://doi.org/10.1016/j.jesp.2006.09.002.

Eisenberg, N. (1982). The development of reasoning about prosocial behavior. In N. Eisenberg (Ed.). *The development of prosocial behavior* (pp. 219–249). New York: Academic Press.

Eisenberg, N., & Miller, P. A. (1987). The relation of empathy to prosocial and related behaviors. *Psychological Bulletin, 101*(1), 91–119.

Engel, C. (2011). Dictator games: A meta study. *Experimental Economics, 14*((4), 583–610.

Fawcett, C., & Tunçgenç, B. (2017). Infants' use of movement synchrony to infer social affiliation in others. *Journal of Experimental Child Psychology, 160*, 127–136.

Fessler, D. M., & Holbrook, C. (2014). Marching into battle: Synchronized walking diminishes the conceptualized formidability of an antagonist in men. *Biology Letters, 10*(8), 20140592.

Fessler, D. M., & Holbrook, C. (2016). Synchronized behaviour increases assessments of the formidability and cohesion of coalitions. *Evolution and Human Behavior, 37*(6), 502–509.

Fischer, R., Callander, R., Reddish, P., & Bulbulia, J. (2013). How do rituals affect cooperation? *Human Nature, 24*(2), 115–125.

Flood, M., Dresher, M., & Tucker, A. W. (2010). *Prisoners' dilemma. Game theory.* Beau Bassin: Beta Script Publishing.

Garcia Coll, C., Garcia Miranda, A., Buzzetta Torres, I., & Nogueras Bermúdez, J. (2018). On becoming cultural beings: A focus on race, gender, and language. *Research in Human Development, 15*(3–4), 332–344.

Garrod, S., & Pickering, M. J. (2009). Joint action, interactive alignment, and dialog. *Topics in Cognitive Science, 1*(2), 292–304.

Green, A., McEllin, L., & Michael, J. (2019). Does sensorimotor communication stabilize commitment in joint action?: Comment on "The body talks: Sensorimotor communication and its brain and kinematic signatures" by G. Pezzulo et al. *Physics of Life Reviews.* https://doi.org/10.1016/j.plrev.2019.01.009.

Guala, F., & Mittone, L. (2010). How history and convention create norms: An experimental study. *Journal of Economic Psychology, 31*(4), 749–756.

Güth, W., Schmittberger, R., & Schwarze, B. (1982). An experimental analysis of ultimatum bargaining. *Journal of Economic Behavior & Organization, 3*(4), 367–388.

Hamann, K., Warneken, F., & Tomasello, M. (2012). Children's developing commitments to joint goals. *Child Development, 83*(1), 137–145.

Hove, M. J., & Risen, J. L. (2009). It's all in the timing: Interpersonal synchrony increases affiliation. *Social Cognition, 27*(6), 949–960.

Ip, W., Chiu, C., & Wan, C. (2006). Birds of a feather and birds flocking together: Physical versus behavioral cues may lead to trait-versus goal-based group perception. *Journal of Personality and Social Psychology, 90*(3), 368–381.

Jensen, K. (2016). Prosociality. *Current Biology, 26*(16), R748–R752.

Jia, L., Tong, E. M. W., & Lee, L. N. (2014). Psychological "gel" to bind individuals' goal pursuit: Gratitude facilitates goal contagion. *Emotion, 14*(4), 748–760.

Kirschner, S., & Ilari, B. (2014). Joint drumming in Brazilian and German preschool children: Cultural differences in rhythmic entrainment, but no pro-social effects. *Journal of Cross-Cultural Psychology, 45*, 137–166. https://doi.org/10.1177/0022022113493139.

Knoblich, G., Butterfill, S., & Sebanz, N. (2011). Psychological research on joint action: Theory and data. *Psychology of learning and motivation. Vol. 54. Psychology of learning and motivation* (pp. 59–101). Elsevier.

Kokal, I., Engel, A., Kirschner, S., & Keysers, C. (2011). Synchronized drumming enhances activity in the caudate and facilitates prosocial commitment-if the rhythm comes easily. *PLoS One, 6*(11), e27272.

Konvalinka, I., Vuust, P., Roepstorff, A., & Frith, C. D. (2010). Follow you, follow me: Continuous mutual prediction and adaptation in joint tapping. *Quarterly Journal of Experimental Psychology, 63*(11), 2220–2230.

Lakens, D. (2010). Movement synchrony and perceived entitativity. *Journal of Experimental Social Psychology, 46*(5), 701–708.

Lakens, D., & Stel, M. (2011). If they move in sync, they must feel in sync: Movement synchrony leads to attributions of rapport and entitativity. *Social Cognition, 29*(1), 1–14.

Lang, M., Bahna, V., Shaver, J. H., Reddish, P., & Xygalatas, D. (2017). Sync to link: Endorphin-mediated synchrony effects on cooperation. *Biological Psychology, 127*, 191–197.

Launay, J., Dean, R. T., & Bailes, F. (2013). Synchronization can influence trust following virtual interaction. *Experimental Psychology, 60*, 53–63. https://doi.org/10.1027/1618-3169/a000173 1 © 2013 by Hogrefe.

Levine, M., Prosser, A., Evans, D., & Reicher, S. (2005). Identity and emergency intervention: How social group membership and inclusiveness of group boundaries shape helping behavior. *Personality and Social Psychology Bulletin, 31*(4), 443–453.

Loersch, C., Aarts, H., Keith Payne, B., & Jefferis, V. E. (2008). The influence of social groups on goal contagion. *Journal of Experimental Social Psychology, 44*(6), 1555–1558. https://doi.org/10.1016/j.jesp.2008.07.009.

Melis, A. P., & Semmann, D. (2010). How is human cooperation different? *Philosophical Transactions of the Royal Society B: Biological Sciences, 365*(1553), 2663–2674.

Michael, J., & Székely, M. (2017). Goal slippage: A mechanism for spontaneous instrumental helping in infancy? *Topoi* (pp. 1–11). .

Michael, J., Sebanz, N., & Knoblich, G. (2016a). Observing joint action: Coordination creates commitment. *Cognition, 157*, 106–113.

Michael, J., Sebanz, N., & Knoblich, G. (2016b). The sense of commitment: A minimal

approach. *Frontiers in Psychology, 6*, 1968.

Miles, L. K., Nind, L. K., & Macrae, C. N. (2009). The rhythm of rapport: Interpersonal synchrony and social perception. *Journal of Experimental Social Psychology, 45*(3), 585–589.

Mills, P. F., Harry, B., Stevens, C. J., Knoblich, G., & Keller, P. E. (2018). Intentionality of a co-actor influences sensorimotor synchronisation with a virtual partner. *Quarterly Journal of Experimental Psychology, 1747021818796183*.

Mitkidis, P., McGraw, J. J., Roepstorff, A., & Wallot, S. (2015). Building trust: Heart rate synchrony and arousal during joint action increased by public goods game. *Physiology & Behavior, 149*, 101–106.

Nash, J. (1950). *Non cooperative games.* (Princeton University PhD dissertation, reprinted in *Annals of mathematics, Vol. 54*, (1951 (September) (1950)).

Pontus, L., & Shah, J. (2013). For whom the goals loom: Context-driven goal contagion. *Social Cognition, 31*(2), 187–200.

Pun, A., Ferera, M., Diesendruck, G., Kiley Hamlin, J., & Baron, A. S. (2018). Foundations of infants' social group evaluations. *Developmental Science, 21*(3), e12586.

Reddish, P., Bulbulia, J., & Fischer, R. (2014). Does synchrony promote generalized prosociality? *Religion, Brain & Behavior, 4*(1), 3–19.

Reddish, P., Fischer, R., & Bulbulia, J. (2013). Let's dance together: Synchrony, shared intentionality and cooperation. *PLoS One, 8*, e71182. https://doi.org/10.1371/journal.pone.0071182.

Rusch, H., & Luetge, C. (2016). Spillovers from coordination to cooperation: Evidence for the interdependence hypothesis? *Evolutionary Behavioral Sciences, 10*(4), 284.

Sacheli, L. M., Tidoni, E., Pavone, E. F., Aglioti, S. M., & Candidi, M. (2013). Kinematics fingerprints of leader and follower role-taking during cooperative joint actions. *Experimental Brain Research, 226*(4), 473–486.

Schelling, T. C. (1960). *The strategy of conflict.* (Cambridge, Mass).

Shockley, K., Santana, M.-V., & Fowler, C. A. (2003). Mutual interpersonal postural constraints are involved in cooperative conversation. *Journal of Experimental Psychology: Human Perception and Performance, 29*(2), 326–332.

Silk, J. B. (2009). Nepotistic cooperation in non-human primate groups. *Philosophical Transactions of the Royal Society B: Biological Sciences, 364*(1533), 3243–3254.

Skyrms, B. (2004). *The stag hunt and the evolution of social structure.* Cambridge University Press.

Staub, E. (1978). Predicting prosocial behavior: A model for specifying the nature of personality-situation interaction. *Perspectives in interactional psychology* (pp. 87–110). Springer.

Stupacher, J., Maes, P.-J., Witte, M., & Wood, G. (2017). Music strengthens prosocial effects of interpersonal synchronization—If you move in time with the beat. *Journal of Experimental Social Psychology, 72*, 39–44.

Székely, M., & Michael, J. (2018). Investing in commitment: Persistence in a joint action is enhanced by the perception of a partner's effort. *Cognition, 174*, 37–42.

Tajfel, H. (1970). Experiments in intergroup discrimination. *Scientific American, 223*(5), 96–103.

Tajfel, H., Billig, M. G., Bundy, R. P., & Flament, C. (1971). Social categorization and intergroup behaviour. *European Journal of Social Psychology, 1*(2), 149–178.

Tomasello, M. (2009). *The cultural origins of human cognition.* Harvard university press.

Tunçgenç, B., & Cohen, E. (2016). Movement synchrony forges social bonds across group divides. *Frontiers in Psychology, 7*, 782.

Turner, J. C., Brown, R. J., & Tajfel, H. (1979). Social comparison and group interest in ingroup favouritism. *European Journal of Social Psychology, 9*(2), 187–204.

Valdesolo, P., & DeSteno, D. (2011). Synchrony and the social tuning of compassion. *Emotion, 11*(2), 262.

Valdesolo, P., Ouyang, J., & DeSteno, D. (2010). The rhythm of joint action: Synchrony promotes cooperative ability. *Journal of Experimental Social Psychology, 46*(4), 693–695.

Van Baaren, R. B., Holland, R. W., Kawakami, K., & Van Knippenberg, A. (2004). Mimicry and prosocial behavior. *Psychological Science, 15*(1), 71–74.

Van Huyck, J. B., Battalio, R. C., & Beil, R. O. (1990). Tacit coordination games, strategic uncertainty, and coordination failure. *The American Economic Review, 80*(1), 234–248.

van Ulzen, N. R., Lamoth, C. J., Daffertshofer, A., Semin, G. R., & Beek, P. J. (2008). Characteristics of instructed and uninstructed interpersonal coordination while walking side-by-side. *Neuroscience Letters, 432*(2), 88–93.

Vesper, C., Butterfill, S., Knoblich, G., & Sebanz, N. (2010). A minimal architecture for joint action. *Neural Networks, 23*(8–9), 998–1003.

Wiltermuth, S. (2012). Synchrony and destructive obedience. *Social Influence, 7*(2), 78–89.

Wiltermuth, S. S., & Heath, C. (2009). Synchrony and cooperation. *Psychological Science, 20*(1), 1–5.

Woolhouse, M. H., & Lai, R. (2014). Traces across the body: Influence of music-dance synchrony on the observation of dance. *Frontiers in Human Neuroscience, 8*, 965.

Woolhouse, M. H., Tidhar, D., & Cross, I. (2016). Effects on inter-personal memory of dancing in time with others. *Frontiers in Psychology, 7*.

Xiao, N. G., Quinn, P. C., Liu, S., Ge, L., Pascalis, O., & Lee, K. (2018). Older but not younger infants associate own-race faces with happy music and other-race faces with sad music. *Developmental Science, 21*(2), e12537.