Coordination in Human and Primate Groups

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Chapter 2
An Inclusive Model of Group Coordination

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Abstract The need for a cross-disciplinary inclusive model to analyse the coordination of human and non-human groups is based on observations that (1) group coordination is a fundamental and complex everyday phenomenon in both human and non-human primate groups that (2) largely impacts the functioning of these groups and (3) continues to be fragmentarily studied across disciplines. We formulate an overview of the basic group challenge (group task) of coordination and describe how the context of the group task regulates the group's *functions* (effectiveness criteria) for achieving their task. We explain the basic *entities* that have to be coordinated and therefore analysed, illustrate the concept of coordination process *mechanisms* by which the entities can be coordinated, and finally argue that these mechanisms have finite characteristics of explicitness or implicitness and can and do occur before and after the core coordination process. We then go into further detail by showing how *patterns* emerge from the various coordination dynamics, and end with a discussion of how the various coordination levels at which coordination operates also need to be analysed with a separate *IPO* (*input–process–outcome*) 'lens' that revolves around the basic analytical model, ensuring that multiple perspectives as well as levels of dissolution (macro, meso, micro) are analysed. In our final section, we review the components of contemporary small group theory and integrate these components into our inclusive functions–entities–mechanisms–patterns (FEMP^{ipo}) model of human and non-human primate small group coordination.

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2.1 Introduction

What is an inclusive model of group coordination, and why do we need it? An inclusive model of group coordination integrates, or – as the name suggests – includes, variables that determine how group coordination works. The need for such a model is based on observations that (1) group coordination is a fundamental and complex everyday phenomenon that (2) largely impacts the functioning of human and non-human primate groups and (3) continues to be fragmentarily studied.

This chapter is organised as follows. We start with a formulation of the basic group coordination challenge, that is, the task-dependent management of interdependencies of individual contributions. In the four sections that follow, we explore the many facets of the coordination challenge, such as coordination entities: the goals, meanings, and behaviours that have to be coordinated as basic psychological levels of analysis; coordination mechanisms: the means by which the entities can be coordinated; coordination dynamics: the emerging coordination patterns; and coordination levels: the levels at which coordination operates. In our final section, we use the results of this exploration of facets of the coordination challenge to integrate these components into a workable inclusive model of human and non-human primate small group coordination.

2.2 Why Coordinate? Task Types and the Coordination Challenge

We define *group coordination* as the group task-dependent management of interdependencies of individual goals, meanings, and behaviours (Arrow et al. 2000) by a hierarchically and sequentially regulated action and information flow in order to achieve a common goal (see also Chap. 1). There is a long-standing concept in small group research regarding the so-called synergistic advantage of group performance compared to the same number of persons individually performing the task (West 2004; Zysno 1998). If the task is additive, the group coordination product can be calculated as the arithmetic sum of individual contributions (e.g. Hill 1982; Shaw 1976; Steiner 1972; Williams and Sternberg 1988). For example, pulling a rope, clapping hands, or brainstorming ideas are typically additive tasks. The power of the individual rope-pullers, hand-clappers, or idea-generators equals the group's performance as a whole, and the sum of the individual ideas, for instance, defines the creativity of the group. In other words, the effectiveness of the group is measured in 'the more (pulling, clapping, ideas), the better' terms.

The consensus among primatologists regarding non-human primate groups is that group cohabitation exists because its advantages (such as consolidation of foraging efforts and strength-in-numbers defence against predators) exceed its disadvantages (feeding competition, disease transmission, mating rivalries) (see Chaps. 13–15 for thorough treatments). In contrast, there exists an argument in the literature of small group coordination that group performance is associated with a net loss in both productivity and efficiencies (Steiner 1972). However, other social scientists appear to side with the primatologists, arguing that a net poor group performance in human groups is unexpected (Caporael et al. 2005; Wilson 1997; Yeager 2001).

2.2.1 Coordination Challenge of Task Synchronisation

This debate within and across multiple disciplines shows in a salient fashion that the effectiveness of group performance – even at its most rudimentary level of additive tasks – is not so much an arithmetical problem but a sociopsychological coordination challenge. In pulling a rope, clapping hands, or generating ideas, people must coordinate their individual endeavours by pulling or clapping at exactly the same point in time; or in the case of non-human primate foraging, perform directional leading; or in human brainstorming, regulate turn-taking. Otherwise, in each of these instances, the contributions of individual group members could not be meaningfully concatenated into a group effort. This problem of synchronisation in time can be solved physically – in the human group examples at least – by pace-makers.

2.2.2 Coordination Challenge of Process Loss

The case of synchronising brainstorming is a bit more complicated, as we know from empirical research reported by Diehl and Stroebe (1987). If people come together in a real group to brainstorm ideas, the pool of ideas created by the group as a whole is smaller than the sum of ideas generated by the same number of individuals as participants of a so-called nominal group. This *productivity disadvantage* (e.g. number of ideas), also known as a *process loss*, of interactive groups compared to nominal groups is to be expected. In brainstorming, evaluation apprehension such as the fear of being evaluated negatively by other participants can hinder the creative potential and/or contribution of group members. Another potential motivational loss is social loafing (Latané 1981; Zysno 1998). One important reason for the reduced productivity of real groups compared to nominal groups is the coordination loss due to production blocking (Diehl and Stroebe 1991; Stroebe and Diehl 1994). People cannot talk at the same time, they must wait their turn in order to express their ideas, and – even more costly to productivity – they tend to forget their own ideas while listening to the contributions of the other group members. The brainstorming group coordination paradigm is a particularly useful example of a group coordination challenge because this so-called productivity loss (reduction in arithmetic sum of ideas) can also be due to a redundancy of ideas: The sum of 'group ideas' is less than the sum of ideas from individual group members if collated pre-process. In the case of brainstorming, group effectiveness is reduced if expressed *quantitatively* (number of ideas reduced due to redundancy), but the actual functional effectiveness can conceivably be increased – especially in cases of brainstorming – if expressed *qualitatively* due to the quality of ideas emerging from group interaction vs. individual members working alone (see Boos and Sassenberg 2001).

2.2.3 Coordination Challenge of Increased Requirements Based on Task Complexity

As can be seen in Table 2.1, coordination requirements increase with the complexity of the group task, and as the complexity of a group task correlates with its coordination requirement, different tasks face different functional effectiveness criteria (Boos and Sassenberg 2001). Interestingly, this coordination requirements–group complexity association can also be present in non-human primate group coordination, as alluded to in Chap. 15 in a presentation of mixed-species coordination. Generating tasks such as brainstorming only requires the coordination of individual goals or task representations. But because participants of the brainstorming process must generate ideas on the same question or problem, a preliminary group discussion on the question or problem will in all likelihood be necessary in order to jointly define the problem (group goal). However, reaching a joint problem definition and formulating a group goal or incentive for the subsequent brainstorming session is not a 'generating' task but belongs to another category of tasks, namely 'problem solving.' Group coordination tasks are categorised as 'problem solving' if there exists a potentially correct or at least optimal problem definition, and are categorised as 'decision making' if the group 'only' has to come to a consensus.

Decision-making tasks are characterised by an opaque structure and a lack of a solution that can often only be clearly perceived as the correct one after the decision has been implemented (Orlitzky and Hirokawa 2001). This task is particularly complex because (1) goals and means of goal achievement are often unclear, making their establishment an important part of the decision-making task itself, (2) they involve high information requirements, as the initial information is typically unequally distributed among group members and a final decision is only

Table 2.1 Task type, coordination requirements, and effectiveness criteria (as per Boos and Sassenberg 2001; McGrath 1984)

Task type	Coordination requirements	Effectiveness criteria
Generating ideas/plans	Problem definitions, goals	Quantity/Quality
Problem-solving	Problem definitions, goals, facts, evaluations	Validity, correctness
Decision-making	Problem definitions, goals, facts, evaluations, opinions, evaluation criteria	Validity, Group cohesion: task commitment, compliance, or consensus

possible via sharing and integrating information, and (3) they also involve high evaluation demands because the correctness of possible decision alternatives cannot be determined objectively (Kolbe and Boos 2009). Additionally, group decisions are not made in a social vacuum but involve social, affiliative, hierarchical, and agonistic aspects (Gouran and Hirokawa 1996).

2.2.4 Coordination Challenge of Other Task Complexities

Distinguishing task types as predictors of coordination requirements is useful because it shows the fundamental impact of the task on the group process. However, its limitations are obvious. In real life, few group tasks are single-faceted brainstorming or decision making in character. Instead, groups frequently face tasks consisting of different levels and qualities of complexity (see Examples 1 and 2 ahead as well as Table 2.2). Examples (and by no means an exhaustive list) of further task-defining aspects are the degree and quality of task interdependence (Grote et al. 2004; Rico et al. 2008), level of task standardisation (Grote et al. 2003), task load (Grote et al. 2010), and task routineness (Kolbe et al. under review; Rico et al. 2008). In order to meet the shortcomings of group task classifications and make more specific predictions on what has to be coordinated when and by whom, it has been suggested that performing group task analysis is helpful in sorting out predictions of task complexities and requirements (Annett 2004; Tschan 2000). For a more thorough treatment on the subject of task analysis as a means for defining group coordination requirements, see Chap. 6.

In Sect. 2.3 we will segue into a finer-grained analysis of coordination requirements, exploring different entities that are to be coordinated in groups.

Example 1: Family Trip
A family (mother, father, 13-year-old daughter, 5-year-old son, plus both sets of grandparents) spends a weekend together. The father suggests a trip to a famous modern-cuisine restaurant at a beautiful lake, which would involve a 2-hour trip together in the car. He is used to his kids' less-than-enthusiastic reactions to such suggestions but not sure how to interpret the smiling 'Sure!' from his parents and parents-in-law and even more irritated by the non-communicative facial expression of his wife.

Table 2.2 Coordination problem of Examples 1 and 2

	Example 1 "Family trip"	Example 2 "Non-human primate group"
Coordination problem	Coordination problem: This familiar group situation shows that a task envisaged as brainstorming most likely also involves classic decision-making components (and lurking problem-solving as well).	This group task includes a variety of different decision-making (e.g. where to go, when to go) and physical activities (e.g. moving both groups safely from one resource to the other).

Example 2: Non-human Primate Group
A mixed-species group of non-human primates moves from one feeding resource to the next (see Chap. 15).

2.3 What Is to Be Coordinated

2.3.1 Entities of Coordination: Individual Goals, Meanings, Behaviours

The coordination problem consists not only of the interdependencies of member-specific activity contributions (behaviours), but also of the coordination of terms and information (meanings), as well as special role expectations and intentions (goals) held by individual members of the group (Boos et al. 2006, 2007). Arrow et al. (2000) structured *goals*, *meanings*, and *behaviours* in an entity-levels pyramid, implying in their hierarchical design by using the label 'levels' that the coordination of individual member *goals* has an innately higher value than the coordination of individual member *meanings* (e.g. terms, information) and *behaviours* (see Fig. 2.1). We prefer not to follow this hierarchical order, as all three entities help define the coordination task itself (input) as well as the activities that will occur in the process stage of the group coordination task (process) and the functions that determine the effectiveness criteria of the group coordination task (output). For example, a case in point is coordinating spatial movements from one feeding resource to the next among non-human primate mixed-species groups (see Example 2 in Table 2.3; see also Chap. 15). Individual *goals* (satiation of hunger vs. wanting to rest), *behaviours* (some members display foraging behaviours while others nurse and care for their young), and *meanings* (some members know trail traits indicating prospective foraging grounds while other members recognise noise, odours, or other information indicating the approach of predators) are coordinated to secure a *collective action* that accomplishes *spatial cohesion* as its *function*. We therefore prefer to use an equal-lined triangle to depict a content model for the entities component of our model, implying that there is no innate hierarchical importance of individual goals, individual meanings, or individual behaviours regarding their influence on the constructs of group coordination.

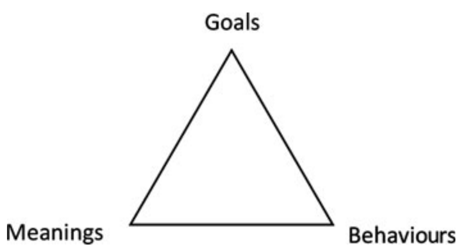

Fig. 2.1 Content model for input and output entities

Table 2.3 Coordination problem and entities of Examples 1 and 2

	Example 1 "Family trip"	Example 2 "Non-human primate group"
Coordination problem	Coordination problem: This familiar group situation shows that a task envisaged as brainstorming most likely also involves classic decision-making components (and lurking problem-solving as well).	This group task includes a variety of different decision-making (e.g. where to go, when to go) and physical activities (e.g. moving both groups safely from one resource to the other).
Coordination entities	Individual goals (satiation of hunger vs. showing off vs. having fun vs. getting it over with without quarrel), meanings (individual ideas of how to spend a day together), and behaviours (walking and driving abilities, who is sitting where in the car) have to be coordinated.	Individual goals (satiation of hunger vs. wanting to rest), meanings (some members know trail traits indicating prospective foraging grounds while other members recognise noise, scent or other information indicating approach of predators), and behaviours (some members display foraging behaviours while others care for their offspring) have to be coordinated.

2.3.2 Coordination of Goals

One of the most likely potential sources of intra-group conflict is a divergence of the goals of individual members. We all can probably recount more than one frustrating group experience where it turned out that we (1) found ourselves speculating about the hidden agendas of our group mates, or (2) had to realise conflicting individual goals within our group, or (3) found that our individual goals were not completely compatible with the group goal. Human groups seem to have an inherent preference to assume within-group goal congruence and avoid an open discussion to explicitly define individual and group goals (Hackman and Morris 1975). This seemingly pseudo-consensus is not necessarily harmful or insincere when group members actually agree on the same goals. However, diversity of interests is present in most cases, making the coordination of individual goals a necessary condition in the majority of cases for successful group functioning. In fact, it has been found that student teams working on a business simulation showed significantly better long-term performance when they made individual goals known in advance of planning their team task (Mathieu and Rapp 2009).

We argue that achieving 'consensus' regarding a group goal can be understood as the explicit or implicit convergence of individual goals to a group goal, or the setting and acceptance of a given group goal, or even a combination of these contrasting egalitarian and despotic processes – the relevant outcome being a single group goal that all group members can strive to achieve. The coordination of goals refers to a motivational process comprising the integration of goals and intentions of group members (Arrow et al. 2000). In a hypothetical example of coordinating goals, one group member might approach a group meeting with the pre-process goal/intent to convince the project manager not to include the project leader presentation, while another member might have the pre-process goal/intent to convince everyone that their former school colleague should be invited to give a talk, while the project manager him- or herself might have pre-process goals/intentions to talk about ideas for guest speakers, how to track the progress of research organisation, and exchange ideas for collaborative projects. All the above pre-process goals and intentions, no matter where the group member is placed in the organisational hierarchy, are individual goals, as they have not yet been coordinated in-process.

In the inclusive model we present, one of the important challenges in achieving effective group coordination is to set group goals that, by definition, can only be set in-process by the group (vs. despotically by the project manager) for a number of reasons, not the least of which is to enhance individual commitment to the group task.

2.3.3 Coordination of Meanings

On the level of meanings, coordination can be understood as the process of grounding and information sharing for the development of a common ground as well as the development of a shared mental model of information and the group task (see Boos and Sassenberg 2001; Poole and Hirokawa 1996; Waller and Uitdewilligen 2008; see also Chap. 10). In a recent interdisciplinary research task among some of the authors of this book, a group of researchers from primatology and psychology attempted to explore the 'Evolution of Social Behaviour.' While making efforts to reach shared mental models within this interdisciplinary research group, it soon became obvious that "meanings" in such a highly diverse group have to do with individual and discipline-specific views, perspectives, and term definitions that in a more homogeneous group can simply be assumed to be shared.

As discussed in Chaps. 10 and 11, achieving a shared mental model often requires reconciliation of the ambiguities and meanings of shared information (e.g. Poole and Hirokawa 1996; Waller and Uitdewilligen 2008). Once definitions of contributed information are settled upon, a shared mental model of evaluation criteria, with the inevitable diverse opinions, preferences, and disagreements, needs to be achieved as well (Boos and Sassenberg 2001; Orlitzky and Hirokawa 2001). Establishing a shared mental model of the group task between pre-process individual goals and in-process group goals is required to accomplish any group task.

The extent of coordination of meanings positively correlates to the extent of explicit and implicit agreement of group members regarding their shared comprehension of facts, tasks, topics, and terminology. Small group studies have shown that a shared mental model is so pivotal to the effectiveness of groups that it is positively correlated to both the risk and the complexity of the group task as well as the adaptability of the group to a dynamic task environment (e.g. Cannon-Bowers and Salas 1998; Cannon-Bowers et al. 1993; Klimoski and Mohammed 1994). A large portion of the challenge of achieving shared mental models is maximising the extent of explicitness in the consensus regarding meanings (for additional details regarding the importance of explicitness concerning meanings, see Chap. 11).

As is generally the case with coordination requirements and the complexity of group coordination, the intensity of the challenge of achieving shared mental models increases pari passu with the diversity of the group (see Table 2.1). Implicit or tacit assumptions regarding terminology are particularly disruptive to joint research efforts, as was alluded to earlier in this section regarding our interdisciplinary project. However, the appropriate degree of explicitness seems to vary among cultures (De Luque and Sommer 2000), implying that the compelling solution of 'the more goal diversity, the more explicitness, and the more effective the group' does not always apply to every setting – once again illustrating the complexity of the coordination problem.

2.3.4 Coordination of Behaviours

On the level of behaviour, coordination can be understood as the synchronisation of actions (behaviours) in time and space – the orchestration of the sequence and timing of interdependent actions (Arrow et al. 2000; Marks et al. 2001). As an example, in the operating room, anaesthesia team members each have different roles that are defined by task responsibilities as well as behavioural expectations during anaesthesia and surgery. Consequently, they have to coordinate their specific actions in a specific manner to be successful, involving measures of both explicit and implicit coordination appropriate to the individual subtasks and medical situation (Kolbe et al. 2009; Zala-Mezö et al. 2009; see also Chap. 5). One could reasonably assume that successful synchronisation of behaviours equates with the group doing the right things in the right order at the right time. For instance, groups having to work on a construction task that plan *before* they start working and *intermittently* stop to evaluate their task performance are more likely to perform well (Tschan et al. 2000). In the same vein, anaesthesia teams have been shown to perform better when their members monitored each other's performance and *subsequently either provided back-up behaviour or spoke up* (Kolbe et al. 2010). Similarly, 'closed-loop communication' involving the receiver of the message acknowledging its receipt was found to improve group performance (Salas et al. 2005). Nuclear power plant control room teams have also been shown to perform better when they exhibited *fewer, shorter*, and *less complex interaction patterns* (Stachowski et al. 2009).

An interesting example of synchronisation of behaviour via leadership in non-human primate groups has been identified in the coordinated group movements in Verreaux's sifakas, an arboreal Malagasy non-human primate living in small groups observed in a study performed by Trillmich et al. (2004). The group movement was initiated more often by female individual movements than by males – and accomplished via leadership, as observations indicated that a specific so-called grumble vocalisation was likely involved in coordinating the group movements.

As in the non-human primate Example 2 earlier, leadership can be defined as a sequence of behaviours, that is, the synchronisation of leadership and followership behaviour. As in other correlations of coordination, the effectiveness of leadership behaviour, such as initiating a group move or making a proposal, is positively correlated to how effective it is in eliciting followership behaviour. For example, the instruction to administer epinephrine is as effective in a reanimation scenario as it is followed regarding the accuracy of timing and dosage of administering. These examples in the literature of the criticality of effective synchronisation of actions illustrate the fundamental role of coordination (see Sect. 2.1).

Depending on the nature of the group task, the three entities of coordination discussed in this section (individual goals, meanings, and behaviours) have a different weight and are focused on to a variable degree. That means that the topic of coordination (both theoretical as well as practical) is complex, as it includes dynamics occurring on the goal-orientation level, the definition of terms level, and the activity (behavioural) level.

Thus, coordination is a multi-level process that references different types of entities to be coordinated and to be synchronised in one and the same process – a process we intend to elucidate further in the upcoming section.

2.4 How Entities Are Coordinated: Coordination Mechanisms

At the next level of dissolution of the coordination problem – from the atomic level of single entities such as goals, meanings, and behaviours – we can discern coordination mechanisms on the molecular level as in those of vocalisation, gesture, and odours (Conradt and Roper 2009).

Mechanisms constitute the ‘toolbox’ or ‘processing machine’ of group coordination that includes, for example, interaction and communication events such as asking questions, soliciting opinions, summing up standpoints, giving exposés on information, grumble vocalisation, and handing a scalpel to a doctor. Coordination mechanisms transform individual input entities of goals, meaning, and behaviour into group processes. As illustrated in Chap. 5, for anaesthesia teams meaning and behaviour are the two important input entities for accomplishing the group task of induction of anaesthesia. As Figs. 5.1 and 5.2 show, these two input entities – by means of coordination mechanisms – transform into the processes of information *exchanges* and *collective* actions. This is a clear example of how, depending on the task type, the emphasis on which group coordination tools are used will change, with different mechanisms occurring more (or less) often and with a different overall importance to the successful execution of the task.

For purposes of simplicity, we frame our use of the process concept of mechanisms in terms of their level of explicitness or implicitness (Entin and Serfaty 1999; Espinosa et al. 2004; Rico et al. 2008; Wittenbaum et al. 1996, 1998; Zala-Mezö et al. 2009) and their temporal occurrence (Arrow et al. 2004; Burke et al. 2006; Fiore et al. 2003; Marks et al. 2001; Tschan et al. 2000; Wittenbaum et al. 1998) (see Fig. 2.2). For a thorough discussion of these dimensions, see Chaps. 4 and 7.

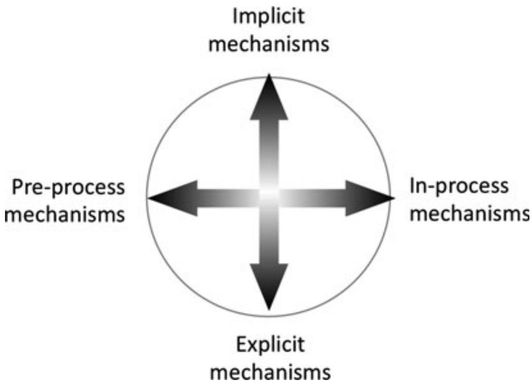

Fig. 2.2 The coordination mechanism circumplex model (CMCM) (adapted from Wittenbaum et al. 1998)

2.4.1 Explicit Versus Implicit Coordination

We regard mechanisms such as verbal or written communication as *explicit coordination* because they are used purposefully, leaving few doubts about their underlying intention. Espinosa et al. (2004) distinguish between two forms of explicit coordination: programming mechanisms (schedules, plans, procedures) and verbal communication, regarding communication itself as a coordinating mechanism. Examples of mechanisms classified as *implicit coordination* are instances when group members anticipate the actions and needs of the other group members and adjust their own behaviour accordingly, for instance, voluntarily handing a surgeon a scalpel, automatically reporting to the team where they currently stand in their group task, or synchronically targeting a flashlight when a team member is making adjustments to a piece of machinery (Rico et al. 2008; Wittenbaum et al. 1996). Contrary to explicit coordination, coordination is reached tacitly through anticipation and adjustment. As indicated in the 'Family trip' Example 1 (Table 2.4), implicit coordination can only be effective if the underlying mental models are shared as well as valid, which, not so surprisingly, is not always the case. Particularly divergent goals, unequal information distribution, and ambiguity of opinions and preferences – all characteristic of more complex and risky decision situations – require a certain amount of explicitness in order to avoid classic cases and consequences of 'miscommunication' ('I thought you got the purchase go-ahead from the boss'; 'I assumed you checked the fuel gauge before takeoff').

Given that explicit coordination as defined by many researchers (e.g. Espinosa et al. 2004) almost exclusively requires language (e.g. for defining rules, giving orders), which as far as the scientific community knows is a unique human accomplishment, one might assume that there is no explicit coordination in non-human primate groups. In fact, even though it is more difficult, it is not impossible to discern explicit versus implicit mechanisms in non-human primate groups (see Example 2, Table 2.4). In movements of non-human primate groups (see Chap. 13), if the designated silverback male in a group of mountain gorillas starts to head in his preferred direction (Watts 2000), one could conceivably construe this

Table 2.4 Coordination problem, entities, and mechanisms of Examples 1 and 2

	Example 1 "Family trip"	Example 2 "Non-human primate group"
Coordination problem	Coordination problem: This familiar group situation shows that a task envisaged as brainstorming most likely also involves classic decision-making components (and lurking problem-solving as well).	This group task includes a variety of different decision-making (e.g. where to go, when to go) and physical activities (e.g. moving both groups safely from one resource to the other).
Coordination entities	Individual goals (satiation of hunger vs. showing off vs. having fun vs. getting it over with without quarrel), meanings (individual ideas of how to spend a day together), and behaviours (walking and driving abilities, who is sitting where in the car) have to be coordinated.	Individual goals (satiation of hunger vs. wanting to rest), meanings (some members know trail traits indicating prospective foraging grounds while other members recognise noise, scent or other information indicating approach of predators), and behaviours (some members display foraging behaviours while others care for their offspring) have to be coordinated.
Coordination mechanisms	Pre-process explicit (having already talked about the trip), in-process explicit (asking the others what they would like to do, organising the trip), post-explicit (learning experience that explicit questions produce an awkward atmosphere in our family), pre-process implicit (expectations about how to spend the day, expectations about how to spend a nice day, assumptions about the expectations of the others, unspoken communication rules), in-process implicit (assuming that the others would like to make the trip and tacitly agreeing), post-process implicit (it seems that nobody wanted this trip even though they didn't say so).	Pre-process explicit (vocalisations), in-process explicit (start heading in preferred direction, vocalisations), post-process explicit (grooming of successful leader), pre-process implicit (orienting oneself in the preferred direction), in-process implicit (some individuals maintaining a particular spatial position within the moving group), post-process implicit (increased likelihood of following successful leader at next occasion).

action as 'explicit' coordination, as there is in all likelihood little doubt among any of the group members that he is initiating a group movement. Also in Chap. 13 is an unconfirmed yet conceivable example of 'implicit' coordination in non-human primate groups in South Africa in which high-ranking female baboons with dependent offspring, because of their reproductive cycle, are interpreted as compelled to stay in the centre of the group or in close vicinity of a male protector instead of taking the lead when leaving the sleeping site (Stückle and Zinner 2008). No explicit signals as such are communicated, yet their movement patterns imply a tacit 'implicit' behavioural mechanism of maintaining a physical position of protection for both themselves and their young – a behaviour that could conceivably be interpreted as a 'shared mental model' as it is not opposed (stopped or contested) by the other members of the group.

2.4.2 Pre-, In-, and Post-Process Coordination

As mentioned at the onset of this section, coordination mechanisms are also classified according to their temporal occurrence. Wittenbaum et al. (1998) were the first to add this second dimension of time, explaining that coordination can take place *before* or *during* interaction (respectively, communication). This second dimension led to a four-cell scheme known as the Coordination Mechanism Circumplex Model (CMCM; see Fig. 2.2), validated in our empirical study in Chap. 4. The CMCM describes these four cells as (1) pre-process explicit: rules, instructions, schedules, routines; (2) in-process explicit: division of labour, communication about procedures; (3) pre-process implicit: assumptions about expertise of group members and task requirements; and (4) in-process implicit: mutual adaptation of behaviour.

For the internal logic of our intended inclusive model of group coordination, we must add a third increment to the temporal dimension: post-process group coordination. In addition to pre- and in-process coordination, we can analytically and empirically identify the result of a coordination activity occurring post-process, specifically the post-coordination mechanisms that are the result of pre- and in-process coordination such as a decision, a different location of the group, or a changed mental representation of the task in the group. In an interview study we found that experienced group facilitators have a very clear grasp of post-process group coordination, perceiving their coordination mechanisms as resulting in specific consequences, which in turn impact further group processes (Kolbe and Boos 2009). For example, after a group has finished a team meeting (in-process), all members leave with explicit and/or implicit out-process tasks (task assignments/ intentions, respectively). These out-process tasks will function as input into the next in-process iteration of the team's group coordination (see Fig. 2.5). An example of post-process group coordination in non-human primate groups would be when inter-specific groups go their separate ways when retiring for the evening. This action results in separate sleeping sites, which, in turn, function as group coordination input the next morning (see Fig. 2.5) when the two groups rejoin for the day as an in-process inter-specific group (see Chap. 15 for additional details).

2.5 How Coordination Evolves: Patterns of Coordination

How patterns of group coordination evolve can be exemplarily explained based on a simple micro-level behavioural sequence (see Fig. 2.3).

Patterns of group coordination can be found on all three entity levels, as described in the next sections.

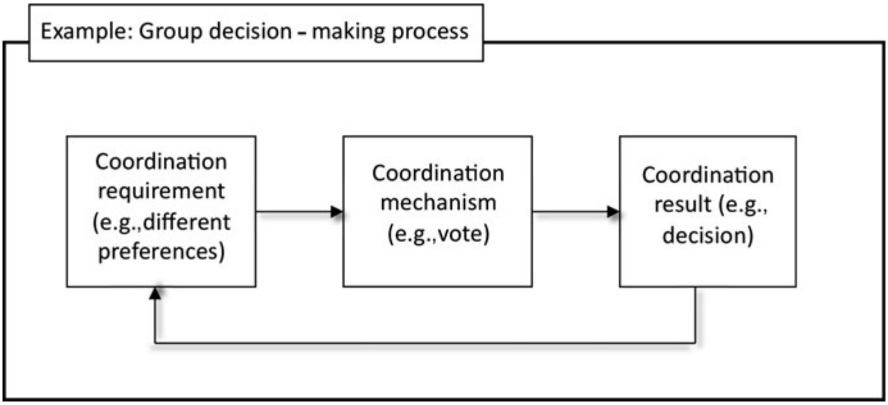

Fig. 2.3 Micro-level work model of group coordination

2.5.1 Goal-Focused Patterns

An example for a goal-focused pattern might be a case of distributed leadership, as in when somebody is presenting her information exposé to the group. During the process of her presentation, she functions as the group leader, holding the floor, steering discussion, and soliciting questions. When she gives the floor back to the project manager, the distribution of the group leadership shifts back to the project manager, where the project manager calls on the next scheduled group member to present his presentation. The leadership role then shifts to yet a third group member. This shared leadership – the dynamic group process among group members who lead one another to help reach the group goals (Pearce and Conger 2003) – has been found to be an effective coordination pattern in a variety of work groups (e.g. Avolio et al. 1996; Künzle et al. 2010b; Pearce and Sims 2002).

Another example of goal-focused patterns was described by Wittenbaum et al. (1996). They showed in an experimental study that group members supplemented others' expected recall when they anticipated a collective recall task (thus aiming to maximise the group's collective recall by remembering information that others likely would not remember), but duplicated others' expected recall when they anticipated a group decision-making task (thus facilitating the emergence of a consensus by focusing on commonly recalled information).

2.5.2 Meaning-Focused Patterns

Meaning-focused patterns can be detected where group members are funnelling idiosyncratic views into shared mental models. An example might be a design team faced with the complex non-routine situation of a creativity task where different experts (e.g. product manager, graphic artist, market statistician) must coordinate their respective expertise, design approaches, and knowledge from diverse organisational fields. That means that the group should first of all produce and differentiate a large number of design ideas in order to develop a comprehensive problem view. This differentiation has to be reduced during group interaction if the group is ever to reach a final design proposal. For that purpose, increased activity towards the integration of concepts must occur. This pattern of first divergent processes (differentiation of ideas) followed by convergent processes (integration of ideas and concepts) is typical for design processes (Boos 2006b). Another example of meaning-focused patterns has been studied by Waller and Uitdewilligen (2008) in their analysis of collective sense-making during crisis situations. They found a pattern they called 'talking to the room,' that is, undirected talk and sharing relevant information to the room at large. Talking to the room invites other group members to actively participate in effective coordination (Kolbe et al. 2010) and has been found to facilitate identifying the accurate diagnosis in medical emergency-driven groups (Tschan et al. 2009).

Meaning-focused patterns in decision-making tasks are particularly interesting. Decision making in groups is often considered a tool for exchanging and integrating their members' diverse expertise and knowledge, discussing a decision problem from different perspectives, and rationally choosing the best of the available options. However, experimental and field studies similar to the one described ahead of how decision making actually takes place often yield a different picture, namely, that initiating group action and maintaining the group's ability to act, rather than rationally elaborating the pros and cons of different alternatives, functionally underlies human group decision making [other functions] (see Kerr and Tindale 2004 for a review). For example, it has been shown that once a significant majority has emerged in the group, the group selectively searches for information supporting the alternative proposed by this majority, instead of conducting an unbiased search for advantages and disadvantages of the different alternatives [processes]. Further hindering the unbiased search for the most advantageous alternative is that dominant members of a group (e.g. those with high formal status) have the strongest impact on the group decision, irrespective of the quality of their arguments. Their proposals and their mode of argumentation turned out to be most successful [processes] (Boos and Strack 2008). This tendency of human groups to bolster an emerging dominant tendency in the group or to overestimate the performance of a member in a high position offers striking parallels to group decision making among some primates.

For example, hamadryas baboons that decide which water hole to visit appear to use similar majority rules to reach a decision about the group's behaviour. Dominance hierarchies occur in most primate species. Individuals with higher hierarchical status tend to displace those ranked below from food and mating opportunities. These hierarchies are not always fixed, however, especially among males, but instead depend on intrinsic factors such as age, body size, aggressiveness, and perhaps cognitive abilities.

2.5.3 Behaviour-Focused Patterns

For example, in a group tasked with reconciling a decision problem (*task type*), there are at least two conflicting prevalent preferences (see Table 2.1). When these distinct perspectives are defined aloud (*coordination requirement*), the group leader can then remind the group that the goal of the group is a consensus (*coordination mechanism*) and that the consequences are that the distinct perspectives, albeit conflicting, both focus on a common basis (*coordination result*). The same processes of reaching a group consensus before enacting a result hold true in groups of gorillas who will not decide about a change in their activities (e.g. leaving their resting site in order to travel to a feeding site) as long as two thirds of the adults have not uttered loud calls (Stewart and Harcourt 1994).

Such sequences can emerge into behavioural patterns, that is, a participative (majority decides) or directive (alpha male decides) style to facilitate group coordination. And yet again, the way patterns tend to evolve within the group will depend on the task focus of the group (goals, meanings, behaviour).

Behaviour-focused patterns are those instances of adaptive coordination, namely, shifting from implicit to explicit behaviour according to the requirements of the task. The adaptability of these behavioural mechanisms in response to a salient cue of the task (e.g. cardiac arrest) and team situation (e.g. resuscitation devices such as a defibrillator being available) leading to a functional outcome (e.g. regained heart activity) is shown to be a prerequisite for patient safety (Salas et al. 2007). Especially the shift from the use of implicit coordination mechanisms in routine phases of task accomplishment to the use of explicit mechanisms in complicated phases seems to be a valid predictor for group performance in anaesthesia (Künzle et al. 2010a; Risser et al. 1999). The effectiveness of adaptive coordination has been shown in a variety of studies (e.g. Grote et al. 2010; Kolbe et al. 2010; Kozlowski et al. 2009; Manser et al. 2008; Waller 1999; Waller et al. 2004).

The advantage of this sequential perspective on the coordination process lies in observing, identifying, and analysing detailed process particulars. We can discover when and under what conditions during the group process particular coordination mechanisms occur, to and from whom the mechanism shifts, and what follows these mechanisms – in other words, what mechanisms are prompted and what their dimensional characteristics are (explicit/implicit; more pre-, in- or post-process), and which coordination mechanisms are ignored (e.g. opening the floor for questions).

The work model of coordination (Fig. 2.3) allowing a micro-level-based process analysis of coordination would not make much sense if it were not embedded in the structural conditions and resources for coordination (e.g. leadership, hierarchy). As this model of the coordination process distinguishes *preceding interactions* from *coordinating actions* and also from *consequences* of the coordinating action, it zooms in on only one segment of the flow of interaction, meaning, or goal/subgoal setting. In most situations, the coordination process is part of a much larger task context or functional requirement to the group (see Example 3).

Example 3: Everyday Work-Life Decision Making in Public Administration: A Field Study" (Boos 1994a, b, 1996)
Part and parcel to core duties of public administration is to weigh and integrate conflicting individual and public interests, for example, economic goals of extending commercial areas on the one hand and preserving ecological resources on the other hand. We found that mainly two ways of steering these heterogeneous goals and problem views were used in the organisations.

We labelled the first way of goal steering 'hierarchical decision making,' characterised by pre-process multi-department-specific criteria regarding their respective preferred decision. The final decision rests with the head of the administrative office, who is responsible for developing a workable solution, even though the departments are expected to contribute to the decision.

We also observed a goal-steering process widespread in bureaucratic organisations that we labelled 'divisional decision making,' characterised by department experts developing a pre-process solution to the problem specific to the point of view of their own department, such as an economic, ecological, or legal point of view. The head of the division was responsible for steering the decision-making process and leading the group to a consensus.

We observed group discussions about a complex decision task and found typical patterns that differentiated quite well between the two coordination strategies. In hierarchical decision-making groups, we found a recurrence of overtaxing of the group by concurrent leadership. In the divisional decision-making groups, we found that everybody had their own agendas, which, by definition, were divergent. Yet knowledge of these agendas, often quite legitimate albeit divergent, was necessary to make the appropriate decision. As small group research has established, the process of collective sharing of individual, contrasting information correlates to the quality of the group decision and can lead to a rather optimal solution (Lim and Klein 2006). The advantage of proceeding hierarchically means coming to a quick decision, mostly based on proposals of the group leader and the use of rhetorical figures of speech to get his or her point across. The disadvantages of the divisional decision-making process is that it takes longer because the success of the final decision is based not only on content but also on effectiveness of arguments related to power, status, and acceptance; additionally, this procedure requires a larger amount of coordination.

2.6 Inclusive Model of Group Coordination

2.6.1 Core Construct of Inclusive Model

From our considerations on small group coordination emerges a trimorphic pattern of components in our model (Fig. 2.5): (1) at the input level, three types of entities are coordinated: goals (*wh*y are we?, e.g. to safely anaesthetise a patient; to forage for food); meanings (*what* are we?, e.g. an anaesthesia team; conspecific groups foraging together); and behaviours [*who* are we?, e.g. via role-defined anaesthetist; or in a non-human primate group, some members defined as need-oriented (e.g. hungry juveniles) and some members defined as solution-oriented (e.g. food-finding lactating mothers)]. These input entities then (2) express themselves at the process 'mechanism' stage, occurring at dimensional levels of explicitness (observable and identifiable vs. often neither observable nor identifiable), and at various points on the temporal spectrum (pre-, in-, or post-process). These dimensions of process mechanisms (3) result in consequent output entities of goals, meanings, and behaviours, feeding back as input such as group-task entities (in the sense of classic functional process models such as the input–process–outcome model by Hackman and Morris 1975; Ilgen et al. 2005). These elements of input *entities*, process *mechanisms* dimensions of explicitness and temporal occurrence, and consequent output operate in an effectiveness-criteria environment *(functions)*. The environment depends on the group task, and fulfilment of functions is measured quantitatively (e.g. the more food, the better), qualitatively (e.g. the patient survives), and/or by the extent to which members either commit to, comply with, or reach consensus of the group task. In general, four basic functions of social systems are discerned (AGIL scheme; Parsons 1937), namely, (1) adaptation, (2) goal attainment, (3) integration, and (4) latent pattern maintenance. In order to manifest these social system functions, a group develops characteristic processes in coordinating their goals, meanings, and behaviours. These processes become manifold, consisting of mechanism-forming *patterns* such as democratic by majority rules, hierarchical autocratic rules, or self-organised.

2.6.2 Peripheral Input–Process–Outcome (IPO) 'Lens' for Examining Varying Levels of Dissolution

Entities, mechanisms, and process patterns can be identified as constitutive at all levels of dissolution in the analysis of group coordination, ranging from the macro- to micro- levels of perspective (see also Klein and Kozlowski 2000). Thus, within our model, the classic IPO systematic is applied as a *device of analysis* rather than as a composite element of small group coordination. We have extended the core of our model by adding an external analytical 'lens' (Fig. 2.4) device to the workings of the model that enables analysis of all levels of coordination dissolution from fine-grained atomic micro-level inter-individual interactions (e.g. initiator–follower behaviour), meso-level routines (e.g. resuscitation algorithms), to macro-level structures of small group coordination (e.g. hierarchical, egalitarian). Our resulting inclusive functions–entities–mechanisms–patterns (FEMP^{ipo}) model therefore offers a practical analytical tool for both human and non-human primate group coordination that can be used at any perspective (e.g. top-down or bottom-up;

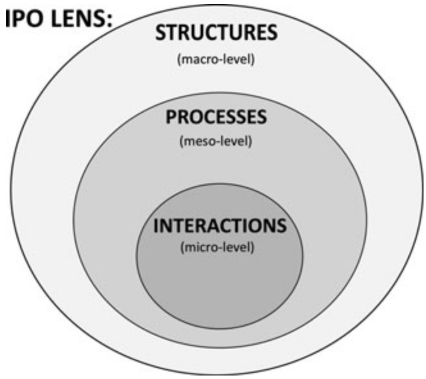

Fig. 2.4 IPO lens of group coordination

input–process–output or output–process–input) and at all levels of dissolution (micro-, meso-, and/or macro- elements).

In order to illustrate the application of the model's IPO lens (Fig. 2.4) more closely, let us return to the example of the public administration decision-making meeting from Example 3. Using this multi-dissolution analysis that the external 'lens' part of our model suggests, on the macro-level, the hierarchical and divisional structures were characteristic for every bureaucratic organisation as well as pre-determined modes of observed decision making. These structures were implemented in role instructions for the group members and the group leader in a free simulation of this public administration case (Boos 1994a). We expected different process patterns on the meso-level of dissolution under these different modes of group decision making (respectively, steering of group processes). In a recent study (Boos 2006a), we reanalysed the videos and transcripts with a combination of quantitative and qualitative methods. On the basis of interaction process coding, we identified coordination episodes in the group discussion. These episodes were interpreted according to the rules of structural hermeneutics (Oevermann 2002). Our intent was to describe the process where the two different organisational procedures (hierarchical vs. divisional) are set into action in the group. It would be naive to contend that the instructions could be implemented one by one via an intentional process such as that of the group leader in this field study, so we instead conceptualised the group process as a combination of intended individual behaviour and the unintended collective results of individual planned behaviour. As others in small group research have concluded, the structural and process levels of group coordination are intertwined and produce emergent characteristics of the group (Poole et al. 1985). In their theoretical approach, Poole and colleagues conceptualise group decision making as a 'structuration process,' meaning that the process is a pattern of interrelated events from which a structured outcome emerges. 'Structuration' in this context means that a social system produces and reproduces itself in an ongoing process via the application of generative rules (e.g. hierarchy) and resources (e.g. technical devices; routines). Applied to the example of group decision making, group decisions are not solitary events but instead more closely resemble iterative concatenations of goal settings, convergence of meanings, and synchronisation of behaviours.

This interplay of structural and process levels corresponds to two basic psychological principles: first, the constructability of a process as in our context regarding the actualisation of a coordination behaviour and its predictable outcome; and second, the spontaneity (non-predictability) of behaviour, which leads to the evolution of a pattern or 'gestalt' that can only partly be traced back to instructions or goals.

The qualitative results corresponded to results we received from detailed process coding and time-series analysis of the data (Boos and Meier 1993). The quantitative data confirmed what we hypothesised in the qualitative study: There are significant meso-level differences between these two models of group coordination (Fig. 2.5) (Boos 1996).

The design of our inclusive model with augmentations such as the embedded four-quadrant Coordination Mechanism Circumplex Model (CMCM) by Wittenbaum et al. (1998) within the process part of its IPO structure and its peripheral 'lens' to facilitate the various levels of analysis helps us to understand coordination on these different levels of dissolution as complementary notions at integrated levels. Often, coordination on the structural level is called *steering* in order to depict that there is a difference in the scope of an expectation horizon: 'Steering' in this sense means expectation-guided orientation (sense or direction) of behaviour in social systems. Coordination relates to the requirement of an ongoing, selective

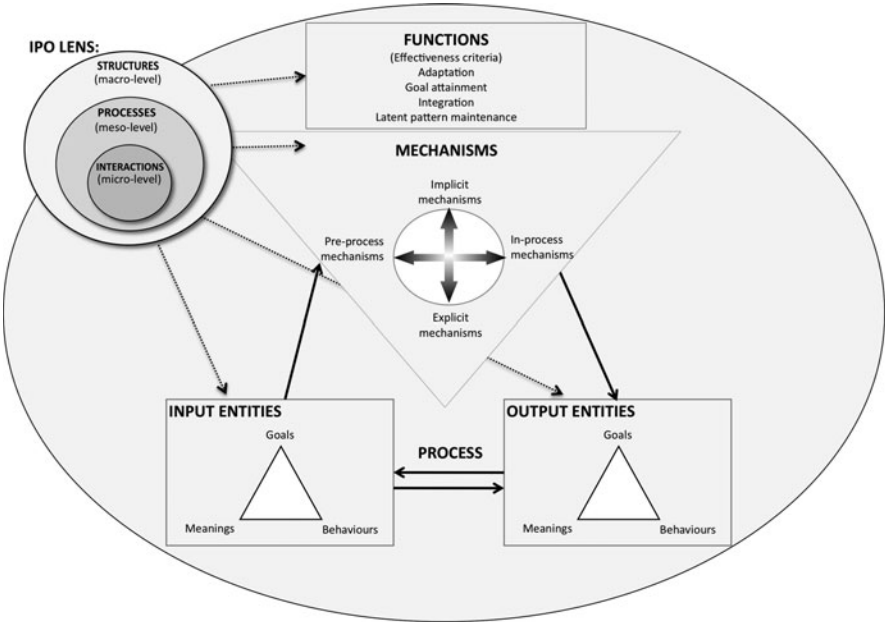

Fig. 2.5 An inclusive functions–entities–mechanisms–patterns (FEMP^{ipo}) model of group coordination

integration of events that consistently appear instantaneous, even though they can exert a long-term impact on economic and ecological structural alterations of a city in cases such as our field study that examined coordination dynamics of public administration decision making.

An example of a multi-dissolution examination of the non-human primate arena is an analysis of leadership behaviour based on maximising survival, which might be assumed to mostly occur on the structural level. Examining non-human primate leadership behaviour on a process level is whether the group – at a specific point in time – moves on the ground or in the trees. And obviously, these various levels of dissolution perspectives are usually not mutually exclusive and should therefore be analysed with assumptions of interactive emergent dynamics *and* linear, sequential cause-and-effect relationships.

2.6.3 Provisions for the Iterative Structuration Inherent in Coordination

In addition to the above differentiations of the levels of dissolution in an analysis of group coordination, depending on the nature of the group and the reasons why the group coordination's task was set up, group coordination can be either a process variable or a result variable and often times is both. As an example, we can focus the coordinated process of sharing mental models via interaction and communication or we can focus – in a specific moment in time – on a shared mental model as a result of this process. Provisions have been made for this phenomenon in our FEMP^{ipo} model, with an arrow circulating from the 'output' stage of the model's core back into the 'input' stage of the model's core.

2.7 Conclusion

Here again we have the distinction between process and structure, which other models have been hard-pressed to address and thus remain in the theory stage versus the field application stage. Generally, coordination relates only to the moment where goals, meanings, and behaviours converge. And this very act of coordination is irreversible. From the structural side of coordination, which, as we mentioned earlier, is often called *steering*, individuals and groups take such moments of convergence as an opportunity to adjust their expectations and thus identify new coordination challenges. In this sense, the difference between steering and coordination corresponds to the difference in the reversibility and irreversibility of events as well as to the difference between structure and process.

It is our hope that this chapter, with its description of small group coordination theory and its consequent inclusive FEMP^{ipo} model for examining coordination elements in groups, has struck a balance between conveying an appreciation for the enormous complexity of group coordination and offering a practical analytical tool for comparative studies of coordination in human and non-human primate groups.

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