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Preface

All members of our species are faced with cooperative decision making and group coordination on a daily basis. By definition, group coordination involves the coordination and reconciliation of potentially conflicting interests of individuals within a group to produce a joint solution. It is therefore cumbersome, time-consuming, and politically problematic. As psychologists, we are learning from cooperative projects with our primatologist colleagues (such as this book) that this weighing of the costs and benefits of group coordination defines the very causal roots of primate group living. Primatological studies reveal that cooperation and coordination are also involved in daily decisions of non-human primate groups, providing an important comparative perspective that is leading to a better understanding of general patterns and mechanisms of group coordination as well as aspects that are unique to humans.

We therefore invite everyone faced with decision making and the challenges that group coordination poses – from family to lecture hall – to explore the essays in this book. Even sole proprietors of entrepreneurial start-ups who regularly make decisions on their own could learn a thing or two from this book about the survival benefits of making those decisions in a cooperative setting instead. Together, these chapters provide a refreshingly comparative perspective on group coordination within both human and non-human primate groups and reveal a stunning diversity of behavioural mechanisms with surprising outcomes. Our goal is to contrast concepts and methods of coordination, which, of course, reveal many differences but also show some interesting similarities. For example, where humans would expect the most dominant, physically powerful male of a non-human primate group to make all decisions, we find that in many cases the needs of the younger and physically vulnerable group members influence pivotal decisions affecting the entire group as well. The survival imperatives underlying successful primate group coordination at the group level make the metaphorical applications to human group coordination boundless and eye-opening. One constant among humans and non-human primate groups appears axiomatic: No one member – no matter how intelligent or talented or multi-faceted – can approach successful group interactions from all perspectives and dispose of all data required for the coordination of the entire group.

The book is organized much like any approach to group coordination would be. Contributions to Part I deal with theoretical approaches, defining the task of group coordination. Chapters in Part II explore scientific concepts and methods of group coordination, offering state-of-the-art data on the subject from different psychological perspectives. Part III presents four aspects on coordination in non-human primate groups that are of great interest for understanding human coordination. The authors provide insights into mechanisms of primate group movement, introduce a variety of communicative signals in different modalities, impress psychologists with rudimentary forms of shared intentionality in great apes groups, and discuss the effects of heterogeneity in primate group composition. At first glance, the reader might think that coordination in non-human primate groups is lacking the essential and most salient aspects of human coordination such as verbal communication and written plans. However, these contributions reveal that there are indeed some important similarities that make this comparison valuable for research and theory.

As is always the case with studies on group coordination, each section approaches its particular focus with the assumption that no research project is ever complete and therefore outlines questions and ideas ripe for future research. Because this is one of the most dynamic areas of inter-disciplinary research, we do not claim that this volume provides an exhaustive summary. However, most readers open to an interdisciplinary approach will in all likelihood encounter perspectives that they have never contemplated before.

Faced with compiling a book on as ambitious a subject as coordination and decision making by human and non-human primates, clearly the best way, and frankly the only way, to present the science on this topic was to do so as a group. This collaborative endeavour allowed us to experience some of the rather practical group coordination challenges firsthand (e.g. choosing contributors, working with and reconciling different ideas of how to edit a book together, coordinating the timing and input of the contributions themselves, etc.). But without a doubt, the richness of its final form benefits from these challenges – a testimony to group coordination itself.

This book is a direct outcome of interdisciplinary cooperation made possible by the Courant Research Centre “Evolution of Social Behavior” at the University of Göttingen in Germany. This centre was founded in 2008 with DFG (German Research Foundation) funding, and its constituent members study the social behaviour of human and non-human primates from an evolutionary perspective. The book’s contributors were largely chosen among the participants of a workshop on implicit and explicit coordination in Göttingen in 2006 that proved pivotal to the establishment of this Courant Research Centre. We would therefore like to express our gratitude to the DFG and the University of Göttingen (which funded the workshop) for ultimately making the publication of this book possible. We would also like to thank the contributing authors, who carved time out of their already over-burdened schedule to compose works that reflect the diversity and creative thought that their fields of research demand. And we extend special thanks to Anette Lindqvist at Springer for her enduring patience as our editor, Margarita Neff-Heinrich for her

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Göttingen, Germany — Margarete Boos and Peter M. Kappeler
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Part I
Theoretical Approaches to Group Coordination

Chapter 1
Coordination in Human and Non-human Primate Groups: Why Compare and How?

Margarete Boos, Michaela Kolbe, and Peter M. Kappeler

Abstract This chapter integrates the six chapters in Part I of this book. They offer different treatments of the theoretical aspects of small group coordination, thereby providing a framework for how coordination behaviour can be studied from the perspectives of social psychology and primatology. Although we have a good working definition of group coordination and have scientifically established that groups of all primates, including humans, are adapted to improve survival, we are less informed about the behaviours that keep groups together and resolve conflicts. Chapter 2 helps to narrow this gap by integrating contemporary thought on coordination and offering an inclusive model for investigators to use in their analysis of both human and non-human primate groups. Chapter 3 informs us about how and why group movements of non-human primates offer a particularly rich arena with which to study primate group coordination. Chapter 4 presents a thorough analysis of a classic tool in group coordination theory (Wittenbaum and colleagues' Coordination Mechanism Circumplex) and how it can be used to understand behaviours of both an observable and tacit nature that occur before and during the actual coordination task. Chapter 5 takes another perspective – that of high-dynamic anaesthesia teams – to show how theories of coordination can be applied to prevent harm in the operating room. The final chapter offers an outline of how the analysis of the group

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task itself can be used to develop categories of group processes and performance, adapting hierarchical task analysis tool for in-depth structural analysis.

Animals as well as humans have inherent tendencies toward group behaviour, a trait considered to be one of the major evolutionary transitions. Group living provides advantages such as protection, efficient foraging, and synergy in task performance (Voland 2000; West 2004). However, living in any kind of group requires coordination of behaviour and/or meanings and/or goals (Arrow et al. 2000; Kappeler 2006; Steiner 1972; Stroebe and Frey 1982).

We define group coordination among human and non-human primates as the goal-dependent management of interdependencies by means of hierarchically and sequentially regulated action in order to achieve a common goal. Group coordination can be analysed regarding its *functions* (e.g. contribution to a group decision or to a joint movement), its *processes* (e.g. democratic or hierarchical), its *mechanisms* (e.g. explicit or implicit), and its *entities* (e.g. level of behaviour, meaning, or goal; Arrow et al. 2000; Chaps. 2 and 7). The core assumption of the social-evolutionary perspective on small groups is that group structure and interaction reflect evolutionary forces that have shaped social behaviours over thousands of years (Poole et al. 2004). Within this evolutionary approach, the contributions to this book and others in the literature of social psychology, primatology, and anthropology demonstrate how social coordination behaviour can be studied from the perspectives of social psychology and primatology. This in turn allows us to provide answers to the anthropological questions of how mechanisms of group coordination have evolved and whether there are unique characteristics of so-called human nature. This evolutionary approach includes a selectionist and adaptionist framework (Daly and Wilson 1999).

The adaptive reasons why most animals live in stable social groups are well studied (Conradt and Roper 2003; Kerth 2010), but the behavioural mechanisms used to maintain group cohesion and to solve conflicts of interest are only beginning to be explored. We will explain this research gap using the example of group cohesion. For most primate species, the maintenance of group cohesion is of primary importance for ecological reasons. Maintaining group cohesion is not a trivial problem because groups can be large and can also contain individuals with valid diverging individual interests. Perhaps more so than any other animal species, humans exhibit behavioural mechanisms that promote and facilitate cohesion at the group level. Social psychological research is concerned with how groups obtain this aforementioned cohesion (Baron and Kerr 2003; Festinger 1957; Forsyth 2006; Williams and Harkins 2003). With some exceptions, of course, in contrast to primatological research that attempts to identify behaviours that lead to cohesion in a group, the social psychological concept is far less behavioural oriented and is based instead on affective states, cognition, or common symbols that promote cohesion. For example, a widely accepted conceptualisation of group cohesion in social psychology holds that cohesiveness can be based on interpersonal liking, prestige of the group, and/or commitment to a common goal (Hogg and Abrams 1989). Thus, comparative studies of human and non-human primate groups could

give way to the inclusion of more behavioural elements in psychological concepts of group cohesion, and at the same time test to what extent affective states, cognition, or common symbols giving rise to cohesion in human groups can also be identified among non-human primates.

As established above, evolution does not require groups only to maintain cohesion, but also to act collectively in order to achieve common goals. Therefore, mechanisms of making collective decisions have to be formulated. Studying the behavioural processes that underlie decisions on the group level such as where and when to forage or rest is therefore a prime example for studies of functional communication and decision processes (Conradt and List 2009; see also Chaps. 12, 13, and 15). Primatology is becoming increasingly interested in how primate groups coordinate their activities by making collective behavioural decisions (Kappeler 2006). As in humans, vocal communication in non-human primates appears to play an important role in mediating decisions at the group level (Trillmich et al. 2004; see also Chaps. 3 and 13). For instance, when separated from conspecifics, many primates give loud calls that can be heard over large distances (Fischer et al. 2001). These vocalisations seem to function as 'contact calls' that are exchanged between widely separated individuals or subgroups (Rendall et al. 1999; see also Chap. 15). Despite their occurrence in specific contexts, there is some doubt about whether contact calls have evolved specifically to maintain contact between separated individuals. Although listeners can use the calls to maintain contact with signallers, signallers may not call with the intent to inform others. In the case of baboons, however, it seems clear that individuals give contact barks because they have lost the sight of others and are feeling anxious (Fischer et al. 2001).

Although there exist such studies of decision making in non-human primate groups, and many coordination mechanisms such as vocalisation and gesture have been identified (see, e.g. Chap. 13), the explicit and implicit signals and rules of communal decision making remain rather poorly understood.

We do know, however, that human group decision making is a widespread phenomenon within families as well as within colleague groups, committees, juries, etc. (Boos 1996). Group decision making has been extensively studied in social psychology (see, e.g. Chaps. 7 and 11). Large numbers of experimental and field studies have been conducted to identify, for example, regularities of information exchange in groups, in order to learn about how initial member preferences are integrated into a final group decision as well as how conflicts of interest are resolved in a group (Gouran et al. 1993; Orlitzky and Hirokawa 2001; Stasser and Titus 1985). Whereas any overview of the vast literature on group decision making clearly lies outside the scope of this contribution, we would like to highlight an interesting pattern evident in human decision-making research: Human decision-making groups are often considered to be a tool for exchanging and integrating their members' diverse expertise and knowledge to gain a more complete understanding of a decision problem from different perspectives and for rationally choosing the best of the available options. In other words, we often conceptualise groups as functioning something like a 'think tank'. However, experimental and field studies

of how human group decision making actually takes place often yield a different picture, namely that of maintaining options of least resistance rather than that of rationally elaborating the pros and cons of different alternatives. For example, it has been shown that once a significant majority has emerged in the group, the group selectively searches for information only supporting the majority-supported alternative instead of conducting an unbiased search for the advantages and disadvantages of extant alternatives (Schulz-Hardt et al. 2000). As further research has shown, it is not only the information search that happens in a biased manner, but also the use of information during decision making which is not only biased but strategic (Schauenburg 2004; Wittenbaum et al. 2004). Even more disappointing but not that surprising, dominant members of a group as in those with high formal status often have the strongest impact on the group decision, irrespective of the quality of their arguments (Boos and Strack 2008). Armed with the knowledge of these tendencies in human group decision making, tools developed by social psychologists are emerging to encourage a more thorough perusal of decision options (e.g. Hackman and Wageman 2005; Schweiger and Sandberg 1989).

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 non-human primates as dominance hierarchies occur in most primate species. For example, when deciding which water hole to visit, hamadryas baboons appear to use similar 'majority rules' paradigms to reach a decision about the group's behaviour. Also, individuals with higher hierarchical status tend to overrule those of lower rank from food and mating opportunities. These hierarchical rankings are not always fixed, however, especially among males, and depend on intrinsic factors such as age, body size, intelligence, and aggressiveness. With origins of human phylogeny traced to our non-human primate ancestors (Chapais 2010), it is not clear how much of decision rules (e.g. dominance hierarchy vs. democratic poll) in humans is due to the intrinsic biology of our brains derived from evolution vs. how much is due to cultural factors. Thus, systematically investigating similarities between human groups and groups of non-human primates regarding how they make decisions appears to promise new insights into the principles that underlie decision processes in human groups.

Although group cohesion and group decision making among human as well as non-human primates are interesting in their own right, evolutionary theory would suggest that the existence of these group social systems implies that they are functional with regard to environmental factors (Caporael et al. 2005). In this respect, primatology and anthropology, on the one hand, and psychology, on the other hand, differ considerably with regard to their temporal focus and considerations of what is functionally successful and what is not. Primatology and anthropology focus on the long-term existential success of group cohesion and group decision making; that is, they ask what patterns of group cohesion and group decision making are functional for group stability and the survival of group members. In contrast, psychological research focuses more on the short-term success of group cohesion and group decision making. Social psychologists are interested in whether

group processes in terms of information exchange or mutual understanding benefit from cohesion or specific types of cohesion (Cornelius and Boos 2003), and how high-quality decisions can successfully be achieved in groups (Boos 1996; Kolbe 2007). Furthermore, social psychological research on group performance is especially concerned with how group processes affect performance in a group by influencing member motivation, member capability, and/or member efforts in the group. An important finding is that as a consequence of these influences, performance in a group is not always 'successful' and can lead to process losses as well as process gains when compared to individual settings (Steiner 1972). For example, collective action in a group can lead to coordination losses among members due to the fact that their problem definitions, their goals, or their knowledge bases cannot be synchronised (Boos and Sassenberg 2001). All such human group processes examined by social psychologists affect performance consequences in the short run (e.g. anaesthesia teams' successful management of critical non-routine events; see Chap. 5), rather than a survival or selection advantage of the group in the long run.

Hence, comparative research on the consequences of group cohesion, group decision making, or – generally – group coordination and other group processes on performance criteria in human vs. non-human primate groups could offer new insights for both disciplines (cf. Wilson 1997; Wilson and Sober 1994). For example, regarding short-term consequences of group processes on performance in non-human primate groups, it is yet completely untested as to what extent the same process losses and gains that have been found in human groups also exist among non-human primates. This investigation of group-specific influences on non-human primates' task-related performance would be interesting in itself (e.g. studying capability gains among non-human primates as a function of social learning in a group), but it might also contribute significantly to our understanding of process and capability losses and gains in human group performance. Another open research question concerns motivation gains and why, under specific conditions, group members exert extra effort in a group situation: Whereas some approaches trace this behaviour back to an individualistic motive (e.g. winning the performance competition and thereby gaining status in the group), other approaches postulate a collectivistic motive (e.g. caring for the group's welfare in itself) (Semmann et al. 2003). Since most non-human primates are likely to lack collectivistic motivations, whereas individualistic motives such as striving for status can be frequently found (Silk et al. 2005), comparative studies of group vs. individual performance in tasks where performance almost exclusively depends on effort could provide interesting new evidence for this open question. Likewise, studies of human groups could take advantage of the long-term survival perspective adopted in non-human primate group research. By more extensively studying real groups in the field over extended periods of time, a more adequate picture of 'successful' human group behaviour might arise. Specifically, we might learn to what extent processes that directly impede the short-term performance of groups might nevertheless be facilitative or even essential for the performance, stability,

and sustainability of a group in the long run. This would be a more consequent implementation of the principle of evolutionary selectivity within human social psychology research.

Thus, it appears that integrating research from social psychology, primatology, and anthropology harbours substantial potential benefits for investigating the main questions regarding the evolution of social coordination behaviour: The question of *how human groups coordinate* can be answered partly by means of psychological research; and the more general question of *how primates coordinate* can partly be investigated by means of research in the domain of primatology. And finally, the questions requiring anthropological research are those that consider *the differences between human and non-human primate group coordination* and *how human group coordination has evolved*. It is therefore the objective of the above-described synergistic interdisciplinary perspective to define basic aspects and evolved psychological mechanisms (Buss 2004) of group coordination and decision making and to provide foundational principles on group functioning (Caporael et al. 2005) via appropriate comparative studies of human and non-human primate groups. Specifically, this means that interdisciplinary approaches for assessing the adaptation and selection of coordination behaviour will have to be found in order to define its contribution to the general fitness of both human and non-human primate species.

We consider this an important contribution to evolutionary theory, based on the expectation that comparisons between a variety of primates should allow for determining convergent developments of social behaviour. Similarities between chimpanzee and human cultures have already been found, indicating that they share evolutionary roots (Boesch and Tomasello 1998; de Waal 2006). Furthermore, an interdisciplinary view on the evolution of social behaviour could increase our knowledge on the outlier position of human behaviour and on the importance of language and higher-order cognitive processes for group coordination such as shared mental models.

Thus, within the research objective of describing the evolution of social coordination behaviour, the following five questions can be posed:

1. Which processes and mechanisms of coordination can be found in human and non-human primate groups?
2. How do coordination processes and mechanisms differ between human and non-human primate groups?
3. What are the costs of different strategies (e.g. democratic vs. despotic) for group coordination (Conradt and Roper 2003; Larson et al. 1998)?
4. What is the role of situational adaptation of group coordination processes and mechanisms, and does it differ between human and non-human primate groups?
5. How are means of verbal and non-verbal communication used for coordination purposes in human and non-human primate groups (e.g. Clark 1991)?

These five questions will be considered in the following chapters of this book, giving a systematic overview of the research from the focal fields of primatology, social psychology, and anthropology.

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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.

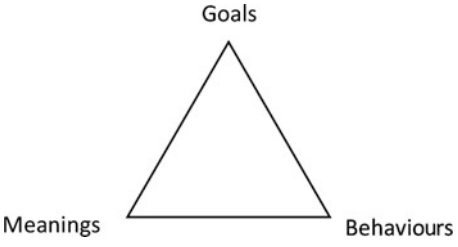

Fig. 2.1 Content model for input and output entities