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All in the Timing

Considering Time at Multiple Stages of Group Research

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The role of time in measuring group and team temporality constitutes more than a methodological issue—it is a theoretical question. That is, if group interaction is theorized as processual and processes occur through time, then research on team temporality, as well as a range of other issues, must grapple with the methodological implications of our theories. This article contributes to INGRoup's aim to advance theory and methods for understanding groups by exploring methodological approaches that allow us to capture a variety of team processes over time. Three case studies address the practical issues involved with employing various types of time-sensitive data collection, time-dependent coding, and time-based analysis, including their advantages and disadvantages. Together, the authors describe diverse field and analytical methods useful for interrogating theoretical assumptions about time in groups. Doing so expands the notion of group temporality to consider the role of both epochal and fungible times at multiple stages of group research.

Keywords: *time; temporality; group; team; methods*

The principle that all methodological decisions should be guided by related theoretical commitments is foundational to social scientific inquiry. Although practical constraints relating to time and timing often make this principle challenging to observe in practice, the study of small group process rests on theoretical assumptions that necessarily call for temporally complex methods. Time is foundational to theories of overall group

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development, theories of the temporal unfolding of processes, such as decision making and conflict, the social entrainment perspective, and complex systems views of temporal change (Arrow, Henry, Poole, Wheelan, & Moreland, 2005; Bales, 1950; Fisher, 1970; Mannix & Jehn, 2004; McGrath, 1991; McGrath & Tschan, 2004b; Moreland & Levine, 1982; Okhuysen & Waller, 2002; Tuckman, 1965; Zellmer-Bruhn, Waller, & Ancona, 2004). Nonetheless, the objective of this article is not to call for more longitudinal research per se (although overtime research is important to apprehend many group processes; Marks, Mathieu, & Zaccaro, 2001) or to call for more research on group temporality (although team temporality is an important predictor of basic team-level constructs; Blount, 2004). Although these are both laudable aims for group scholarship, our shared methodological concern in this article is not simply *more* time but the *right* times. Specifically, through three case studies, we demonstrate specific methodological and analytical tools that invite scholars to take into account both event-based (epochal) and clock-based (fungible) times in the design, coding, and analysis phases of group research.

Bluedorn (2002) describes epochal and fungible times as opposing points on the same continuum, where epochal times are characterized by increasing temporal distinctiveness and fungible times are characterized by increasing temporal equivalence, but where the two regularly intermingle. All group processes unfold in both fungible times that are measured by a clock and epochal times that are intrinsic to the group and its activities. For instance, within an *epochal* conception, time is defined by a larger system of behavioral patterning: It exists in the context of identities, relationships, and interactions that can only be reckoned within broader expanses of time. In contrast, within a *fungibl*e conception, time is defined by external measure, independent of persons and their relationships. In effect, on the fungible extreme of the continuum, all times are the same, and on the epochal extreme, all times are different. Rather than representing a dichotomy, fungible and epochal time constitute a largely neglected duality that, together, offer more informed, fuller conceptions of human temporality.

Both epochal and fungible times are relevant at least at three different stages of research on groups. First, in the design phase, the timing of data collection will determine whether one captures important endogenous patterns such as regularized events and group developmental processes (framed in epochal times, e.g., weekly rituals, socialization, etc.) and critical exogenous rhythms such as daily schedules and project deadlines (gauged in fungible times, e.g., particular times of the day, month, or year). Next, in the coding phase, sensitivity to epochal times in how key constructs are operationalized permits scholars to effectively capture processes that are unique to each group, such as natural segments and ideal sequences that must be coded using a range of fungible times. Finally, in the analysis phase, methods that are designed to capture nonlinear, even interrupted, patterns reveal otherwise hidden group processes that reflect unique, epochal team temporalities.

Likely owed to our shared interest in issues of human temporality more broadly, each of the present authors has sought to take time seriously at these varied stages of group research so that our theoretical approaches are reflected in our methodological choices. This article offers several lessons learned along our respective journeys in this ongoing project centered on time in groups. Below, we offer three case studies that, together, speak to group researchers from a range of methodological backgrounds. What each of our narratives have in common is a sensitivity to timescale (Monge & Kalman, 1996; Zaheer, Albert, & Zaheer, 1999) and, specifically, attention to event-based (epochal) as well as clock-based (fungible) times. We offer variety in terms of the span of time investigated, the nature of the groups and their interactions, and our specific methods.

We address three guiding questions about time in group research, respectively: What difference does the timing of the data collection make? What difference does the temporal unit of analysis make? and What difference does the focus on patterns make? Below, each of the present authors addresses one of these three questions, in turn, based on her respective research experiences. We begin with the first author describing the data collection efforts involved in a longitudinal study employing experience sampling and diary methods. This is followed by the second author's discussion of coding issues concerning the unit of analysis—the natural segment and ideal sequences—as part of exploring time in groups. Finally, the third author considers a data analytic method (i.e., a pattern recognition algorithm, used to uncover embedded patterns). We end by summarizing the major contributions of these case studies taken together.

Case 1. The Timing of Data Collection: Using Experience Sampling and Diary Methods in Group Research

Recently, organizational and group scholars have witnessed a rise in the popularity of studies of workplace and team temporality. Within the past several years, *Academy of Management Review* (2001, 26[4]), *Work &*

Occupations (2001, 28[1]), *Academy of Management Journal* (2002, 45[5]), *Organizational Studies* (2002, 23[6]), *Culture and Organization* (2004, 10[1]), and *Small Group Research* (2004, 35[1]) have all had special journal issues dedicated to this very topic. This does not even take into account all the myriad individually located articles on the subject that have been published in about the same time period or, notably, the *Research on Managing Groups and Teams* volume on *Time in Groups* edited by Sally Blount (2004). What once was an overlooked, understudied aspect of group life (Blount, 2004) has become a fertile ground of scholarly inquiry. From virtual team research to studies of time famine, and from group synchronization investigations to exploring temporal variation across groups, implicit in much of this research is the assumption that both fungible and epochal times enable and constrain team members' shared temporality. The broader theoretical and practical implications are rarely problematized, however (for notable exceptions see Ancona & Chong, 1996; Blount, 2004; Bluedorn, 2002; McGrath & Kelly, 1986; Waller, Zellmer-Bruhn, & Giambatista, 2002). The case study described in this section will consider an appropriate methodological approach to address these issues.

Investigating Group Entrainment Processes: Team Temporality Over Time

The guiding theoretical framework for my work (Ballard, 2007) is the entrainment perspective developed by McGrath and Kelly (1986) and elaborated by Ancona and Chong (1996) and Bluedorn (2002). The concept of entrainment originated in the biological sciences as a way to describe the process by which one cyclic process becomes disrupted by, and set to oscillate in tune with, another process. Group researchers have appropriated this construct to describe how particular sociotemporal patterns develop (Ancona & Chong, 1996; Futoran, Kelly, & McGrath, 1989; Kelly & McGrath, 1988; McGrath & Kelly, 1992). The application of this biological process to theoretical analyses of human temporality is explained as follows:

> Numerous physiological, psychological, and behavioral cycles can become entrained to or modified by powerful social and environmental cues. The social entrainment model provides a framework for describing the operation of such endogenous, rhythmic processes, their coupling to one another and potentially to outside pacers, and the temporal patterns of behavior resulting from those rhythms of human behavior. (McGrath & Kelly, 1986, p. 80)

Essentially, the internal rhythms of individuals and group members can become *collectively* entrained, or synchronized, to powerful external pacers, called *zeitgebers*, altering the phase, periodicity, or magnitude of their endogenous rhythms. This rhythm creates a dominant temporal ordering that exists as a compelling coordination mechanism in teams and organizations. As the number of cycles captured by this rhythm increases, it becomes inertial—as in the case of the semester term or fiscal year.

Early in my research employing questionnaire methods in the field, I experienced an important theoretical and methodological epiphany about entrainment processes. While attending a team meeting to collect questionnaire data and observe the local work environs, a respondent (engaged in completing the questionnaire) asked me a critical question: Should I answer the questions according to how things are today or based on our busy season? In that moment, I realized that questionnaire methods (Ballard & Seibold, 2000, 2004) were only partially sensitive to our construct of interest: time. Although the instrument was literally all about time (including self-report measures of flexibility, linearity, pace, punctuality, delay, separation, scheduling, scarcity, urgency, present temporal focus, and future temporal focus), it was ironically limited by its own timing. I already drew on the social entrainment perspective in my theorizing, but this experience heightened my commitment to finding methodological tools that reflected my theoretical approach.

The Experience Sampling Program (iESP)

The search for effective ways to organize data collection on team temporality across multiple and extended timescales led me to employ experience sampling methods with the use of personal digital assistants (PDAs; Barrett & Barrett, 2001) complemented by paper-and-pencil diary methods (Robinson & Godbey, 1997). Using experience sampling methods, participants answer a question or set of questions (in this case, displayed on their PDAs) at key times prompted either by the participant (which is designed to capture epochal times) or the PDA (which is designed to capture fungible times). The advantage to this method is that it effectively eliminates issues of proper memory recall regarding feelings and attitudes and allows data to be collected over time. These studies are typically carried out during the course of a few days. In this section, I offer a case study of my experiences with a data collection project carried out during the course of 4 months with a student group (Ballard & McGlone, 2008). Whereas my coauthor, Matthew McGlone (University of Texas at Austin), and I are currently in the coding and analysis phases, the focus here is on the study design and lessons learned about the deployment process. My objective is to reflect on the process of designing and executing the data collection—highlighting the possibilities and sharing the challenges—so as to open dialogue with other group researchers interested in measuring processes that occur over extended periods of time.

Using iESP

Getting started. Based on Barrett and Barrett's (2001) excellent discussion of the advantages and disadvantages of computerized experience sampling and the promise of wireless networking solutions, I sought to reduce participant burden as much as possible. To avoid requiring respondents to visit a lab to upload their data to my computer, I selected Palm Tungsten-C WiFi PDAs so that students would eventually be able to hotsync or upload data wirelessly. Additionally, given the long-term (semester long) deployment of the study, I wanted students to be able to use them as actual PDAs (and not simply data collection devices) as a means of compensation for participating. The original Experience Sampling Program (ESP) software did not allow the PDAs to be used for any functions apart from the study, so my research assistant had this specially modified for this project. The developer of the original open source ESP software (Barrett & Barrett, 2001) connected us with a developer (Pauline Powledge of Intel Research Seattle) who had modified it and renamed it iESP for more current PDA models. She then modified iESP further for my needs.

Study design. To identify the zeitgebers (i.e., exogenous pacers) shared by a group of 14 communication students enrolled in an honors seminar, each student was issued a PDA loaded with iESP as a data collection medium to record their experience of time (i.e., their pace and sense of urgency) at specific moments in time and throughout different points in the semester. Students were asked to complete both pace and urgency subscales (for a total of 10 items—5 for each scale) four times a day during the morning (9 a.m. to 11 a.m.), afternoon (1 p.m. to 3 p.m.), evening (5 p.m. to 7 p.m.), and night (9 p.m. to 11 p.m.). The definitions of morning, afternoon, evening, and night were determined through discussions with the group about their shared time frames of what *times* constituted each period: Thus, fungible times were used to capture epochal ones. The 2-hour window was necessary to accommodate both early and late risers as well as to allow students time to complete the trial by minimizing time conflicts with particular appointments or scheduled classes. This occurred 7 days a week (Sunday through Saturday) during the same shared 3 weeks in the semester that constituted the beginning, middle, and end of the term. In addition, pencil-and-paper diaries that detailed each minute of students' time throughout the day were used to augment the PDA data. The timing of the data collection allowed me to tap shared differences in group members' experience of time based on the epochal qualities of the following: certain days of the week (Zerubavel, 1985), particular points in their shared project life cycle contained by a semester (Ancona & Chong, 1996), and the time of the day (Bluedorn, 2002), all of which are potential zeitgebers as described in the time literature. As with most work teams, these shared events are also punctuated by a variety of individual, idiosyncratic events recorded in their time diaries. Apart from differences in mundane activities such as participation in other student groups and hanging out with friends and significant others, there were more notable differences that might differentiate their experience of time. For instance, one participant attended a funeral during deployment and another ran a campaign for election as president of the student government. Thus, the diaries allow us to capture potentially unshared, personal zeitgebers. The identical diary form used in the national Time Diary Studies (Robinson & Godbey, 1997) was used in this project. Because there is a long history of research using the diary method, in the remaining section, I will highlight the more novel aspects of the study primarily associated with the experience sampling procedures.

Lessons Learned and Research Recommendations From Case 1

The reliance on technology in data collection carries special rewards and costs. The ability to carry out theoretically and empirically robust studies, as a result of the unique features of programs like iESP, top the list of rewards. Notably, with iESP, the time stamp associated with each response to ensure that respondents are not merely recalling but are reflecting the experience of their day-to-day lives offers an enormous advantage over typical paper-and-pencil measures. Nonetheless, as described below, there are potential costs associated with the logistics of employing this method.

Challenges. Prior to the first successful deployment of this method, the project was piloted unsuccessfully twice. Finding that the first pilot group suffered from data loss because of problems with data retrieval (i.e., not having a fast and simple way for them to get the data back to me), I began working with a software developer on developing an intuitive server database where respondents could upload their data on a regular basis from anywhere they had a WiFi connection. This additional innovation was piloted a year after the first trial. After fixing some technical problems uncovered during that second pilot, the project finally met with success in the following semester—no data were lost and respondents were able to send it wirelessly. However, even in this success, one respondent allowed her battery to die and—although the data were not lost—the time stamps became meaningless because she did not reset the clock. The total number of development hours is difficult to ascertain because of the rolling nature of the development and troubleshooting process. However, it took approximately two full years for the first successful deployment. This suggests that a fundamental prerequisite of this type of method is time (in the fungible sense). This includes time to coach respondents through the process (making sure that their batteries remain charged), time to answer respondent questions about how to send data, and time to fix any problems uncovered in early pilot tests. Importantly, this project had one part-time research assistant (the same assistant) through the whole process, beginning with the pilot phase.

In addition to technological challenges, throughout the process of working with approximately 200 participants across more than 2 years (including pilot and actual respondents), the project lost (either to actual loss or damage) six units at a cost of approximately $400 each. Relying on multiple costly machines deployed for long times in the field with respondents can, at times, be precarious. However, based on a total of 70 units deployed, this represents a loss rate of less than 10%. This suggests that equipment budgets should anticipate a modest margin of loss. Notably, this problem was reduced once we observed the pattern of damage and developed a "Do's and Don'ts" equipment handout, reviewed in detail with participants prior to deployment. Only one participant (in the pilot) actually lost her PDA; the rest had damaged screens owing to sharp objects (e.g., pens, keys, etc.) loose in book bags. In addition to warning students of this potential in our training, we also distributed a low-tech solution—a rubberband—to keep the protective cover in place over the screen.

Finally, the fatigue reported by participants in keeping up with a study (carried out during the course of 3 weeks in the semester) was noticeable by the end of the deployment period. They reported it being fun though challenging in the first week, but as the time went on, by the second and third weeks of deployments, it became more and more challenging. Shorter time periods will inevitably carry less risk of response fatigue. In this case, students consistently reported that having a PDA for their own personal use was adequate compensation. One concern about this form of remuneration is that in an age of Smartphones where more people have their own PDA, the value of this reward might be rapidly declining. During the early planning stages of this study (in 2003, before obtaining the equipment or designing the study), I conducted an informal poll in a class with 60 students, and only 1 of 60 owned a PDA. Today, the numbers are starkly different with the diffusion of Blackberries, Treos, and the iPhone.

Triumphs. While coding of the diary data described earlier took two research assistants approximately a year because of the large sample obtained (approximately 300 days, which included a variety of relational and task-oriented data), the experience sampling data resulted in more than 1,000 data points of members' experience of urgency and pace during the course of almost 600 individual trials. Preliminary quantitative results evidence a temporal patterning (or entrainment process) consistent with a shared exogenous pacer (i.e., the semester), reflecting a punctuated equilibrium model. Although traditional techniques, like diaries, can be used to approximate the knowledge gained through experience sampling methods, diaries are typically completed retrospectively and at respondents' leisure. (Many reported using a retrospective method for the accompanying paper-and-pencil diaries they kept for this study.) In contrast, iESP provides a date/time stamp giving respondents an incentive to complete it at the appropriate time. This allowed me to obtain an in-the-moment record of how they experienced time at certain parts of the day or week or semester. Additionally, the intuitive Web-based interface through which the data can be uploaded and stored allowed respondents to connect to the server wirelessly from anywhere with a wireless Internet connection. This is a significant improvement in the deployment of experience sampling procedures.

In Case 1, we addressed the importance of considering time in the earliest phases of research (i.e., design and data collection). In addition to the use of a temporally complex study design and data collection method, in Case 2 below, Franziska shares her experiences with time in the next phase of research: determining the proper temporal unit of analysis within which to code group interaction. Specifically, she discusses the role of epochal and fungible times in determining natural segments and ideal sequences in group process.

Case 2. The Coding of Temporally Dependent Constructs: Finding Natural Segments and Ideal Sequences in the Group Process

An increasing number of scholars emphasize the importance of considering time-related aspects in the study of groups and teams (Ancona, Goodman, Lawrence, & Tushman, 2001; Kelly & McGrath, 1988; McGrath & Tschan, 2004b; Waller et al., 2002). This has often been understood mainly as a recommendation to study groups and teams over an extended period of time. For example, Harrison and colleagues noted that almost 90% of the studies in this field are based on either short-term experimental groups or cross-sectional investigation of teams (Harrison, Mohammed, McGrath, Florey, & Vanderstoep, 2003). Here, however, we argue that issues of time go further than the consideration of long-term investigations. There are many time-related aspects, and many of them can and should be studied even in research on short-term laboratory or ad hoc real groups.

Our emphasis is on conceptions of temporal aspects beyond the fungible times contained by clocks and calendars. Several authors (Ancona et al., 2001; McGrath & Kelly, 1986; McGrath & Tschan, 2004a) present different temporal parameters that are important for process research of groups. These parameters represent different examples of Bluedorn's (2002) concept of epochal or event-time. For example, Ancona and colleagues (2001) established a list of temporal patterning in the group process, such as *frequency* of an activity in a given time frame, *repetitions* of activities, or *sequences* of multiple activities during a process. Other possible temporal patterns are *rate* of an activity, *duration* of a behavior, *rhythmic patterns*, linear or nonlinear *trends*, *sudden shifts*, and so on (McGrath & Tschan, 2004a).

This variety of possible temporal patterns is not well reflected in group process research, even in studies where the group process is directly observed. First, there are only a few theoretical propositions of temporal patterns of short-term group processes (Arrow et al., 2005; Arrow, Poole, Henry, Wheelan, & Moreland, 2004). Second, traditional methods of group process coding and analysis often do not take into account temporal aspects (McGrath & Altermatt, 2001; Weingart, 1997). If they do, they tend to treat time-related aspects in fungible terms where the temporal units are treated as comparable and completely exchangeable. For example, the coding unit often is a single behavior or utterance or speech turn. For further analyses, these units are aggregated and represented as frequencies or proportions over a group session or parts of it. This allows investigating group behavioral styles, but it does not capture dynamic aspects of the group process (Weingart, 1997). If sequential patterns are included, this is often done by using whom-to-whom matrices (Bales, 1950; Shelly, 1997), thus, mainly concentrating on adjacent behaviors, and this often does not take into account important aspects of these behaviors (e.g., whether someone introduced a new topic or reacted on a topic). Several statistical methods regularly used to analyze temporal patterns, such as time-series analysis, lag-sequential analysis, or Markov chains, also treat the units analyzed as exchangeable and presume very regular sequential and rhythmic patterns in the group process (McGrath & Altermatt, 2001; Weingart, 1997). However, temporal patterns of group processes are often neither regular nor rhythmic.

Natural Segments in the Group Process

Group processes are often clearly segmented and have different distinct and observable phases, but such segments and phases typically are not regularly distributed over time and correspond much more to the conception of epochal time than to the conception of fungible, exchangeable time.

We distinguish here between two main types of temporal segments in group processes. Note that temporal patterns related to group development are not discussed in this article. On one hand, there are general, longer phases in the group process. This has been shown by Poole (1983a, 1983b), who analyzed decision-making groups and described phases as intertwined threats of activities related to task process behavior, to behaviors related to the relationship in the group, and to topical focus. These phases did not follow regular or rhythmic patterns; they differed in length, and the start and end of phases on the different levels did not often coincide. He then analyzed the pattern of those phases to distinguish different types of decision-making groups.

On a more molecular level, distinct segments of behavior may be identified in the group process. For example, when groups perform a manual task, a researcher may want to investigate how much and what type of attention the group pays to different aspects of the task and code the utterances of the group with regard to this criterion. Depending on the task and the group, some parts of the task may be completed in a very short time, whereas others would need more discussion. As a result, the time a group pays attention to one or another aspect of the task or the number of utterances devoted to a similar theme may be very different. Thus, temporal segments defined by this criterion are most likely of different lengths, spread unevenly throughout the group process and may also vary between different groups. Such segments correspond well to what Poole and Roth (1989) called *normal breakpoints* and Futoran et al. (1989) labeled *related cycles* in the group process. These are described as a "series of acts, usually, though not necessarily contiguous in time, that relate to the same task content or process contribution" (Futoran et al., 1989, p. 222).

Furthermore, in addition to the temporal segments described above, group processes may be divided through the occurrence of *critical events*. These may well be singular events, such as a member joining or leaving the group (Levine, Choi, & Moreland, 2003), the often studied midpoint transition (Gersick, 1989; Okhuysen & Waller, 2002), or an external event to which the group must adapt (Waller, 1999). Critical events can also be repeated events, such as the period during which the group concentrates on a given task, the moment a group switches its attention between two tasks, or even periods of nonactivity (e.g., interruptions). Again, such critical events do not have to be composed of temporally adjacent acts. For example, Boos (1996) studied the fate of suggestions that were mentioned in group discussions. Here, the event (i.e., discussing a specific suggestion) included the suggestion itself as well as all later discussions of the suggestion, even if the discussions occurred much later.

Because these natural segments often show only weak and irregular patterning, there may be limits to detecting those using standard computerized tools, such as time-series or Markov chains. Futoran and colleagues (Futoran et al., 1989) and Poole (Poole, 1983a), therefore, suggested a double-layer coding. The first coding refers to acts (e.g., on a second-to-second basis or on the basis of utterances) and the second step to phases or events. For example, one may code who talks to whom about what as the first coding and, then, as a second coding, code all acts that are related to the same content before an attention shift occurs. Such coding can be done reliably as they have demonstrated (Futoran et al., 1989). Researchers may also predefine events, based on theoretical considerations, and then actively search for such events in the group process.

Example 1: Critical events in medical emergency groups. To illustrate how different approaches to group process analyses can be fruitfully combined in group process research for ad hoc groups, we draw on our study on the importance of leadership in medical emergency–driven groups (Tschan et al., 2006). This is a simulator study, and the scenario presented to the groups reflected features of a typical emergency situation. In this situation, immediate action is required by those who witness the emergency (in this case, three nurses). At the same time, they must call for help, which leads to additional members joining the team—first, a resident physician and then a senior physician. Thus, three phases of group composition can be distinguished. If group members are unacquainted but under time and performance pressure, leadership can be a crucial performance factor (Zaccaro, Rittman, & Marks, 2001) because the group has not yet established good routines for collaboration (Von Cranach, 1985). Therefore, we analyzed leadership and its relation to performance. To determine who took the lead, the proportion of all leadership utterances during each phase of group composition by each person present was measured, and these proportions were compared. As one would expect, in most groups, the first responding nurse took the lead but passed on the leadership role to the incoming resident in Phase 2, who shared it with the senior doctor in the last phase. Here, a classical aggregation and frequency counts of observed units was appropriate and reflects an overall feature of each of the phases of group composition. However, in many situations, there may be critical moments for incoming leaders to influence group performance. We hypothesized that the incoming expert's behavior in a short time window immediately after joining the group may be crucial and could be seen as a critical event. In line with our hypothesis, the amount of leadership of the incoming resident in the first 30 seconds was related to group performance. Note that the amount of leadership during the whole phase was not related to performance, which underscores the importance of the critical event defined. Note also that the same relationship did not hold for Phase 3, where the senior doctor joins, because requirements are different depending on whether other experts are present or not. Thus, leadership behavior in the first 30 seconds after the resident joined was related differently to the outcome variable than similar behaviors of the senior physician in the first 30 seconds after he or she joined. In this study, the variable in question was operationalized as the frequency of a given behavior (leadership). However, its importance was limited to a specific time frame (the critical event), which was chosen on the basis of theoretical considerations.

Example 2: Temporal structuration of segments in the group process and group performance. In a second example, we show how temporal aspects of segments themselves can be important. Based on theoretical considerations about cooperation and coordination in groups (McGrath, 1991; Von Cranach, Ochsenbein, & Valach, 1986; Weingart, 1992), it was hypothesized that groups working on a manual task performed better if segments of their task-related behavior conformed to a specific temporal sequence. In an ideal sequence, group members verbally *initiate* each task or subtask (e.g., by planning), execute it, and terminate it verbally by communicating the progress toward the goal (i.e., monitoring). This temporal sequence hypothesis was tested in experiments where groups had to solve a manual task (Tschan, 1995, 2002). Note that the segments analyzed in this study were of different lengths as they referred to natural breakpoints: Most of the segments contained between 2 and 5 utterances, but some were as long as 20 utterances As hypothesized, groups with a higher proportion of ideally structured segments (i.e., segments that begin with an initiating [planning] communication and end with a monitoring communication) performed better, and this result was obtained both with dyads and with groups of three (Tschan, 1995, 2002). Note that the proportion of planning units or the proportion of monitoring units over the whole group process was not significantly related to performance. Only when the sequential structure of segments—their internal temporal patterning—was taken into account could the relationship with performance be detected.

Lessons Learned and Research Recommendations From Case 2

The passage of time is only one of many temporal aspects that are important for group research. Temporal patterns can take many other forms. Taking them into account is not only cumbersome in terms of coding, but it also leads to a dilemma: Temporal patterns are often specific to certain groups, reflecting epochal times for this specific group. This is shown, for instance, in the example where the arrival of new members defines the critical events in the group process. Furthermore, temporal patterns often cannot be understood without taking the group task into account, as shown by the example of ideal segments, the definition of which is based on an understanding of the (sub)tasks at hand. If coding systems capturing temporal aspects have to be tailored to each task and group, they may not be comparable across different groups, tasks, or situations, thus limiting generalizability (McGrath & Altermatt, 2001; Weingart, 1997). The dilemma lies in the necessity to develop codings that are general enough to be generalizable but specific enough to capture what is important in a given group situation. It can only be solved if the coding systems that take time and tasks into account are developed according to comparable theoretical assumptions, criteria, and guidelines. For example, if task analysis is done in a comparable way, then the lower levels of analysis are very specific, but the broader categories are comparable.

Thus far, we began in Case 1 by offering a data collection method to apprehend epochal times in our study design and moved in Case 2 to the coding phase where we addressed the significance of determining the proper temporal unit of analysis if we are to capture epochal temporality in our data. Now, in Case 3, Mary describes her use of a pattern recognition algorithm in the final (analysis) stage of research to detect nonlinear, even interrupted, temporal patterns. She shows how the proper analytical tools can help reveal otherwise hidden group processes that reflect these unique, epochal team temporalities.

Case 3. The Analysis of Temporal Patterns: Using a Pattern Recognition Algorithm in Group Research

> There is still only one sufficient reason for studying the group: the sheer beauty of the subject and the delight in bringing out the formal relationships that lie within the apparent confusion of everyday behavior. (Homans, 1950, p. 453)

Groups are fascinating social entities—dynamic microcosms of our interactive, relational world. Flowing through the group experience are multiple currents of social and task-focused behavior. These currents are composed of patterns of behaviors that bifurcate and merge over time, resulting in an amazing (and often seemingly unpredictable) variety of group outcomes in a given context. Stable patterns of behavior in groups can form remarkably quickly (Gersick & Hackman, 1990), can be quite difficult to change (Feldman, 1984), and can result in significant consequences in terms of group effectiveness (see Ginnett, 1987; Waller, 1999).

Studying patterns of behavior in groups is important in terms of specifying the dynamic, unfolding nature of groups, but these patterns exist beneath the surface of the group, indeed embedded within the apparent confusion of everyday group behavior, and are difficult to specify as they occur in situ. As Magnusson (2000) notes, "even though unaided observers often perceive human behavior in interactions as somewhat structured and repetitive, they find it difficult or impossible to specify what kinds of patterns are being repeated or when" (p. 93). Furthermore, warnings about deriving information on such dynamic processes from cross-sectional research abound (see Kraemer, Yesavage, Taylor, & Kupfer, 2000, for an example), leading many researchers to seek alternative methods that allow the identification of patterns as they emerge over time.

This desire to uncover underlying patterns of behavior in groups has led to a variety of longitudinal methods being used among group researchers. Here, I focus on the use of a pattern recognition software algorithm in identifying significant patterns in sequential strings of group behaviors. These strings of behaviors were produced by two trained observers who coded the presence or absence of 10 task- and interaction-oriented behaviors within 10-second intervals. They did so while watching 15-minute video recordings of 18 two-person flight crews' interactions during their pre-flight preparations in a flight simulator. My description of the algorithm, its use, and behavioral observation methodologies in group research is decidedly descriptive and idiosyncratic, rather than being a review of methodologies available. By using this approach, however, I hope to offer useful insights for researchers weighing the costs and benefits of such approaches.

The *Theme* Algorithm

Several pattern recognition software packages exist for identifying patterns of behavior. My coauthors, Fred Zijlstra (Maastricht University) and Sybil Phillips (University of Illinois, Urbana-Champaign), and I chose to use the software algorithm *Theme* (see Magnusson, 2000), and my description of it here is based on the description we provide in our work (Waller, Zijlstra, & Phillips, 2007).

The *Theme* software has been used for a number of years by researchers in psychopharmacology (Lyon & Kemp, 2004), child development (Tardif et al., 1995), child psychology (Willemsen-Swinkels, Bakermans-Kranenburg, Buitelaar, van Ijzendoorn, & van Engeland, 2000), animal behavior (Martaresche, Le Fur, Magnusson, Faure, & Picard, 2000), and sports performance (Borrie, Jonsson, & Magnusson, 2002) to detect nonobvious temporal patterns of behavior. Patterns of interaction and behavior can be extremely difficult to detect with the naked eye, especially when other behaviors interrupt the temporal sequence of the behaviors forming a pattern. Such patterns may also be extremely difficult, if not impossible, to detect with procedures such as time-series analysis or Markov chains (Magnusson, 2000), which rely more heavily on fungible times.

In general, the *Theme* algorithm identifies patterns in sequential data by using three steps. First, the algorithm identifies simple temporal patterns—or T-patterns—of two behaviors that occur in time-coded sequential data significantly more often than by chance. A T-pattern is a combination of events in which the events occur in the same order with the real-time differences between consecutive pattern components remaining relatively invariant or stable (Borrie et al., 2002, p. 846). As explained by Magnusson (2000), if A occurs earlier than B in the same recurring T-pattern, "then after an occurrence of A at t, there is an interval [t + d1, t + d2] (d2 ≥ d1 ≥ 0) that tends to contain at least one occurrence of B more often than would be expected by chance" (p. 94).

Second, after simple two-behavior T-patterns are identified, the algorithm cycles through the data, building more complex hierarchical patterns of relationships among T-patterns. This so-called bottom-up approach of pattern detection identifies simple patterns first and then detects larger patterns as a combination of the simpler ones. Finally, the algorithm eliminates patterns that are less complete versions of other patterns. For example, as explained by Borrie et al. (2002),

> a pattern Q = (ABCDE) may be partially detected as, for example, (ACDE) or (BDE) or (ABCE); since elements of Q are missing, these three patterns constitute less complete descriptions of the underlying patterning. A newly detected pattern Qx is thus considered equally or less complete than an already detected pattern Qy if Qx and Qy occur equally often and all events in Qx also occur in Qy. In this case, Qx is eliminated. (p. 847)

The algorithm allows the user to select frequency and probability requirements for the patterns detected. In our analyses, we chose to include only those patterns that occurred at least three times during the time we observed our groups (i.e., on average, occurring at least once every 5 minutes), and we required a 95% probability that patterns occurred above and beyond chance.

Using *Theme*

Using flight instructors' judgments of flight crews' performance levels (high or low) to cluster the crews, we were disappointed to find virtually no significant difference between the two clusters in terms of the frequencies of the behaviors we coded. Turning to the software algorithm, we formatted the string of sequential data for each crew for use with the algorithm and ran the pattern recognition analysis. The software offered several useful measures of the characteristics of significant patterns embedded in our data. For example, we measured the number of significant patterns of behavior that occurred per crew, the number of levels in pattern hierarchies per crew, the length of patterns, and the number of unique single-actor patterns and their occurrences for each crew. Single-actor patterns are patterns of behavior that involve only one actor, such as one actor posing a question and then answering it himself or herself.

Using these *Theme*-generated measures in *t*-test comparisons of high versus low performing crews, we found almost all the measures to be significantly different ($p < .10$). During preflight preparations, high-performing crews engaged in more simple patterns of behavior that indicated much more reciprocity and balanced communication than did low-performing crews. A subsequent discriminant function analysis supported the ability of these pattern characteristics to accurately categorize the crews as high or low performers.

Lessons Learned and Research Recommendations From Case 3

As illustrated by our results here, some previous work has also indicated that how behaviors in groups are distributed over time, rather than how much behavior occurs, can lead to an alternative view of group processes over time and their subsequent outcomes (see Waller, 1999; Waller, Gupta, & Giambatista, 2004). However, the approach to studying patterns of behavior in groups illustrated here is not without drawbacks. Obviously, the ability to detect patterns of behavior and the veracity of those patterns is highly dependent on the accuracy of the data coded from recordings of groups. Although several software products (such as Noldus' *The Observer* and Mangold's *Interact*) exist that are designed to facilitate coding procedures using either video or audio recordings, the accuracy of coding still hinges on the training, calibration, and motivation of human coders. The coding of video or audio data by human coders remains a time and resource bottleneck in this type of research. And although programs exist to provide continuous measures from audio or video recordings, such as paralanguage characteristics like voice pitch or intensity, using these tools in group settings has proven difficult (Bruntink, 2007), and their appropriateness for testing hypotheses of interest to groups researchers at large may be limited.

In a recent conversation on the ability of group researchers to detect patterns of behavior over time in groups, Professor Paul Goodman of Carnegie-Mellon University remarked that we must begin an earnest dialogue with the computer scientists and mathematicians who may have the tools necessary to aid us in automating the coding of behavioral data and detecting patterns of behavior in groups. Given the advances in local computing technology, their tools no longer necessarily require supercomputing power, and they seek new arenas of applied contexts in which they can test and refine their work. Group dynamics researchers may be able to offer such contexts. They have the mechanisms and we have the data, which would seem to offer a nice match.

Many researchers have noted that organizations now face unprecedented levels of environmental dynamism and turbulence and that the move to group- and team-based organizational structures is generally thought to offer a measure of flexibility in such environments. Given this increase in group-based work, the need to specify and understand patterns of group behavior and their relationship to differential outcomes is a need that exists in industry as well as in academe. It is time, and indeed our responsibility, to leverage and apply tools developed in disparate areas—computer science, mathematics, media communication, and others—to more accurately uncover patterns obscured by apparent everyday confusion and ultimately link those patterns to organizationally relevant outcomes.

Summary

The role of time in measuring group and team temporality constitutes more than a methodological issue: It is a theoretical question that comes into play at least at three different times in studying group process. First, a theoretically driven understanding of the timescale within which the process unfolds is necessary, along with data collection methods that can contain that time. Second, after establishing the appropriate timescale, determining the appropriate temporal unit of analysis within that timescale is critical for the validity of subsequent analysis. Third, the temporal sensitivity of our data analytic choices must be appropriate both for the timescale and the temporal unit of analysis. Together, these choices preserve the theoretical assumptions that guide our selection of methodological tools.

The case studies described in this article are designed to open dialogue about the varied challenges and rewards of considering epochal time at multiple stages of group research. Moving beyond a primary focus on *more* time in group research, our cases offer a shared focus on methodological tools and approaches for finding the *right* times, adding another layer of complexity to the issue of time in groups. Notably, we offered detailed accounts of various temporally complex methods to move from theoretical discussions to empirical expeditions across a range of group types and settings. Although we share a theoretical and practical perspective, each case describes the difficulties and triumphs associated with studying epochal times unique to that research setting. Below, we summarize the lessons learned from these various cases, offering practical suggestions based on our experiences.

Case 1 focused on the data collection methods used to find shared and unique epochal times during the course of 4 months in a student group. The primary challenges in this experience sampling study centered on the technological and response requirements. First, the extensive use of technology to collect data inevitably carries the risk of hardware and software irregularities as well as logistical problems and equipment loss. Additionally, active data collection methods (as opposed to the use of archival data) necessarily carry the risk of response fatigue for participants. Nonetheless, despite the modest (if troublesome) risks, experience sampling procedures are ideally suited for active data collection methods intended to capture the relationship between epochal and fungible times. Coupled with diary methods, these procedures yield a wealth of quantitative and qualitative data about shared and unique temporal experiences among group members. Our recommendation from this case is to allot enough (fungible) time for piloting experience sampling studies so that the limitations (i.e., logistic challenges) are minimized and the rewards (i.e., large amounts of triangulated data) are maximized.

Case 2 focused on the coding approaches used to capture epochal times among emergency medical teams engaged in simulator training and experimental groups solving a manual task in the laboratory. The primary challenge of coding temporal patterns in both group contexts centered on the very definition of epochal time: It can be unique to each group and not amenable to predefined coding schemes. In the emergency medical teams, careful task and theoretical considerations led the researchers to a finding regarding leadership that holds only for the first 30 seconds of a unique phase. These first 30 seconds represented a critical event in phases where the resident joined the team (but not when the senior doctor joined the team in a later phase), marking an epochal time in this team context. Similarly, the specific sequence of task behavior in an experimental problem-solving group predicted performance, but the proportion of those same behaviors were not related to performance. This reflects the unique meaning of a behavior for group members depending on when it occurs. Our recommendation from this case is that to properly observe the importance of timing to group process and outcomes, each study must consider the relation of the task setting to the theoretical assumptions about the group process. Whereas the lower levels of task analysis will be specific to each group setting, the broader, theoretically derived categories can then be comparable (permitting generalizability across groups).

Finally, Case 3 presented a data analytic method used to investigate differences in the communication patterns between high- and low-performing flight crews. This approach relied on a pattern recognition algorithm that enables researchers to detect patterns of behavior embedded in epochal times and impossible to predict otherwise (i.e., within a fungible conception). The chief difficulty with such a sophisticated analytic tool is that it still relies on the extensive coding of video data through traditional means. The reliance on 10-second intervals made this a considerable task for human coders. However, following the coding phase, in the present study, the algorithm pointed to important communication differences between high- and low-performing crews during preflight preparations. Note that the frequency of those same behaviors did not predict performance but that the timing of the behavior was meaningfully different, reflecting an epochal time in the crews' flight tasks. The logistic challenge of this data analytic method leads to the general recommendation that group researchers, as a community, seek interdisciplinary collaborations with mathematicians and computer scientists to find tools that can automate the coding process and permit more analyses of this type to proceed (at a faster rate).

If group interaction is theorized as processual and processes occur through time, then research on team temporality, as well as on a range of other issues, must grapple with the methodological implications of our theories. This article contributes to INGRoup's aim by exploring methodological approaches that allow us to capture a variety of group processes that unfold across epochal and fungible times.

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