Founding Editor's Note

One of the most exciting developments in social and behavioral methodology is the development of diary methods, or as they have come to be known, "intensive longitudinal methods." I remember in the late 1980s hearing Harry Reis discuss a whole host of interesting findings using the Rochester Inventory Record, which was an early instrument used in diary studies. As was the case for many methodological advances, substantive researchers like Reis were asking questions from the data for which methodologists had not developed the proper statistical tools—or if there were the proper tools, they were buried in the statistical literature. Additionally, practitioners did not have access to computer software to obtain the proper answer to these questions. After Reis's talk, Deborah Kashy and I began work on a diary study with the goal that she and I would advance quantitative methods in this area. Very early on we realized that we were in way over our heads in this area, and we sought out someone who could assist us in this project. That person was Niall Bolger.

I first met Niall at a cocktail reception in Buffalo at the meeting of the Society of Experimental Social Psychology. Niall at the time was a postdoctoral fellow at the University of Michigan. To steal a line from *Casablanca*, this was "the beginning of a beautiful friendship." Niall appreciated the importance of diary methods in our field, and he had an understanding of the difficult statistical

and computational issues in this area. After Niall moved to New York City, I even convinced him to visit the village of Storrs to continue our collaboration, and he convinced me to visit Gotham several times.

I have not known Jean-Philippe Laurenceau, or J.-P., for as long or as well, but I do know that he has been integral to the successful development of this book. Like Niall, J.-P. has both the statistical and substantive interests, his area of interest being clinical psychology. Like Niall, J.-P. is a dedicated scholar. I remember a meeting a few years back at a University of Massachusetts conference on dyadic data analysis, and both Niall and J.-P. were up until 3 in the morning making the final changes to their presentation.

The book does an excellent job of explaining the usefulness of intensive longitudinal methods, and provides both an intelligent and intelligible discussion of a topic of compelling interest. It discusses why and when you would want to use these methods; how you would collect such data; the analysis of such data; and the meaning of these analyses. For each, substantive examples and computer setups are given. I feel very privileged to have played a role in bringing this book to fruition. Enjoy.

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Introduction to Intensive Longitudinal Methods

Like its companion, the *Handbook of Research Methods for Studying Daily Life* (Mehl & Conner, 2012), this volume highlights the value of studying people in their natural settings. Although laboratory experiments can be powerful tools for testing theories about social and psychological processes, for practical or ethical reasons many of these processes do not lend themselves to experimentation. Even in cases where experiments can be conducted, phenomena demonstrated in the laboratory may not actually occur in the real world. For these reasons, we see great value in studying social and psychological processes as they unfold naturally and believe the best way to do so is to use intensive longitudinal methods.

Intensive longitudinal methods involve sequences of repeated measurements sufficiently frequent to allow one to characterize a separate change process for each subject (which can be a person or other sampling unit such as a dyad or group). By characterize we mean not only the functional form of the change but also its causes and consequences. The purpose of this book is to provide guidance on how to do so.

When conducting nonexperimental studies, researchers in the behavioral and social sciences have traditionally relied on

questionnaire surveys, longitudinal studies, and behavioral observations. There is no doubt that these methods have provided many important insights. Nevertheless, what these methods have lacked is a focus on what Gordon Allport (1942) called the "particulars of life" and what Wheeler and Reis (1991) call the "little experiences of everyday life that fill most of our working time and occupy the vast majority of our conscious attention" (p. 340). Intensive longitudinal designs permit this kind of focus and allow us to realize Allport's vision that "Psychology needs to concern itself with life as it is lived, with significant total-processes of the sort revealed in consecutive and complete life documents" (p. 56).

A second justification for these methods comes from the work of Peter Molenaar (2004; Molenaar & Campbell, 2009). According to Molenaar, almost all biological and social processes are nonergodic, which means that regularities found by comparing subjects (or other sampling units) with one another are unlikely to mirror regularities in how subjects change over time. In other words, if one wishes to understand within-subject changes, one must either directly produce those changes through experimentation or obtain measurements on them as they evolve naturally. Research designs based on observing between-subjects differences will not suffice. Hamaker (2012) presents a compelling discussion and several examples of nonergodicity within the context of intensive longitudinal data.

Now for a more specific definition: an intensive longitudinal design involves sequential measurements on five or more occasions during which a change process is expected to unfold within each subject (e.g., person or other sampling unit). Although specifying a minimum number of measurements is somewhat arbitrary, we chose five because with five observations it is possible to estimate within each subject a linear model with an intercept, a slope for time, a slope for a prior value of the outcome, and a slope for one putative causal antecedent. Such a model would indeed be minimal, having just one degree of freedom to assess the goodness of fit. Nonetheless five observations could be descriptively and graphically informative about change for a given subject over a particular time interval, and if the observations were combined with data from many persons in a suitable multilevel model, it could be very informative about the typical subject.

1.1 WHAT ARE INTENSIVE LONGITUDINAL METHODS?

New researchers embarking on research in natural settings face a frustrating impediment: the variety of names used to describe relevant methods. Experience sampling, daily diaries, interaction records, ecological momentary assessment, ambulatory assessment, and real-time data capture—these all share fundamental similarities that are obscured by terminology. Although the term *intensive* has been used in the past to describe the dense measurement in these designs (Almeida & Kessler, 1998; Bolger, 1990; Bolger, DeLongis, Kessler, & Schilling, 1989; Stone & Shiffman, 1992), it is Walls and Shafer (2006), in their edited volume, who are responsible for coining *intensive longitudinal* as an umbrella term. One of us was a contributor to the volume (Boker & Laurenceau, 2006) and to the meetings at Penn State University that preceded it. As a result of that experience and of our perception that the lack of an overarching term is impeding cumulative work and training efforts, we have chosen to adopt theirs.

To date there are a number of general reviews of research using intensive longitudinal methods (Bolger, Davis, & Rafaeli, 2003; Laurenceau & Bolger, 2005; Reis & Gable, 2000; Shiffman, Stone, & Hufford, 2008; Wheeler & Reis, 1991). Authored and edited volumes summarizing intensive longitudinal research in particular domains (e.g., psychopathology by Delespaul [1995] and deVries [1992]; behavioral medicine by Stone, Shiffman, Atienza, and Nebeling [2007]) have also appeared. A volume devoted specifically to experience sampling methods was published in 2006 (Hektner, Schmidt, & Csikszentmihalyi, 2007). Also, Stone and Shiffman (2002) provided useful guidelines for reporting intensive longitudinal studies. Most recently, the *Handbook of Research Methods for Studying Daily Life* (Mehl & Conner, 2012) has provided a comprehensive overview of various forms of intensive longitudinal methods.

1.2 APPLICATIONS OF INTENSIVE LONGITUDINAL METHODS

The two earliest published accounts of intensive longitudinal research that we located are *How Working Men Spend Their Time* (Bevans, 1913)

and *Round about a Pound a Week* (Pember-Reeves, 1913), both of which focused on how individuals use their time. An early and influential intensive longitudinal study was by sociologists Sorokin and Berger (1939), who asked a sample of individuals to record the starting and stopping times of daily activities, whether others were present, and the motivation for the activity. Some of the earliest work in personality and social psychology was by Csikszentmihalyi and colleagues (Csikszentmihalyi & Larson, 1984; Csikszentmihalyi, Larson, & Prescott, 1977), who studied emotional processes in the daily lives of adolescents; Wheeler, Reis, and Nezlek, who invented the Rochester Interaction Record for use in research on daily social interactions (Reis, Nezlek, & Wheeler, 1980; Reis & Wheeler, 1991; Wheeler & Nezlek, 1977); and Diener and colleagues (Diener & Emmons, 1985; Diener & Larsen, 1984), who studied patterns of mood across situations in daily experience. Other notable pioneering work was conducted by Hurlburt and Sipprelle (1978), Hormuth (1986), and Pawlik and Buse (1982).

The intervening years have seen the expansion of these methods to a wide range of topics including personality processes (e.g., Bolger & Zuckerman, 1995; Fabes & Eisenberg, 1997); affective processes and dynamics (e.g., Barrett, 2004; Kuppens, Oravecz, & Tuerlinckx, 2010), physical health (e.g., Stone & Shiffman, 1994); racism and sexism in daily life (e.g., Swim et al., 2001, 2003), developmental psychopathology (e.g., Schneiders et al., 2007), mental health (e.g., Alloy et al., 1997), and drug and alcohol problems (e.g., Litt, Cooney, & Morse, 1998).

An area of notable growth in the use of intensive longitudinal methods is the study of interpersonal processes in dyads and families (see Laurenceau & Bolger, 2005, for a review). One of the first applications of intensive longitudinal methods to close relationships was by Wills, Weiss, and Patterson (1974), who examined the link between daily pleasant and unpleasant behaviors (over 14 days) and global ratings of marital satisfaction in seven nondistressed married couples. Since then, a growing number of studies have taken advantage of intensive longitudinal procedures to investigate marital and family phenomena, including work on intimacy in marriage (e.g., Laurenceau, Barrett, & Rovine, 2005), work–home spillover (e.g., Repetti & Wood 1997), family emotional transmission (e.g., Larson

& Almeida, 1999), the effect of marital conflict on child outcomes (e.g., Cummings, Goeke-Morey, Papp, & Dukewich, 2002), and family regulation of emotion (e.g., Perrez, Schoebi, & Wilhelm, 2000). Because intensive longitudinal studies of dyads and family members present unique methodological and data-analytic challenges, we devote Chapter 8 in this book to the collection and analysis of dyadic intensive longitudinal data.

1.3 WHY USE INTENSIVE LONGITUDINAL METHODS?

One of the fundamental benefits of intensive longitudinal methods is that they can be used to examine thoughts, feelings, physiology, and behavior in their natural, spontaneous contexts. The data that result can show the unfolding of a temporal process, both descriptively and in terms of causal analysis. Thus, for example, it is possible to examine how an outcome *Y* changes over time and how this change is contingent on changes in a putative causal variable *X*.

Although traditional longitudinal designs can also examine temporal unfolding, they are often limited by few repeated measurements taken over long time intervals. If a researcher is interested in examining the degree to which intimacy fluctuates within a marriage, a longitudinal design consisting of four or five assessments over months or years would likely be inadequate. Because intimacy is theorized to vary over the course of daily interactions (Reis & Shaver, 1988), the density of assessments needs to reflect the underlying theory of change. Moreover, depending on when a variable *X* measured at one point in time has its maximal causal effect on *Y* at a later point in time, the precise temporal design of a longitudinal study can greatly influence the observed effects (Collins, 2006). Intensive longitudinal designs allow researchers to directly capture these day-to-day (or within-day) processes.

In our definition above, intensive longitudinal methods have sufficient repeated measurement to permit researchers to characterize a within-subject process. All too often, hypotheses about within-subject processes are tested using between-subjects data. Consider the following two approaches to studying the link between stressful events and negative affect. In the first, a researcher obtains stressor

and emotion data at one point in time for a sample of individuals. In the second, stressors and emotion are measured on several occasions for a particular individual (or a sample of individuals). Will both approaches yield similar results? Most likely, no. The first approach can determine whether individuals who report more stressors also tend to report higher levels of negative affect. The second can determine whether occasions when an individual's stressors are higher are occasions when the individual's negative affect is higher.

A similar contrast can be drawn when assessing whether anxiety and depression are correlated. In a between-subjects approach, measures of anxiety and depression are obtained at one point in time from a sample of individuals. In a within-subjects approach, anxiety and depression are measured on a number of occasions for a particular individual (or sample of individuals). If we observe that those individuals who are higher than others in anxiety tend to also be higher than others in depression, this does not imply that on occasions when an individual is higher than usual in anxiety the individual will be higher than usual in depression. Although such an inference does not follow either logically or mathematically, in the social and behavioral sciences, we often make inferences about within-subject processes based on between-subjects associations (Borsboom, Mellenbergh, & van Heerden, 2003; Molenaar & Campbell, 2009). By contrast, intensive longitudinal methods permit us to answer questions within subjects, while also allowing us to determine whether these processes are mirrored in between-subjects associations.

Of course, these designs involve important trade-offs. These include increased cost to the investigator in terms of data management, complexity of data analysis, and (increasingly) management of technology for data collection (e.g., PDAs, online web surveys). There are also increased costs to participants in terms of level of intrusiveness. To get a sense of this, we invite readers to imagine themselves being in a study where they are asked to complete a brief diary after every social interaction lasting 10 minutes or more over the course of 7 consecutive days. Although there are many people who could take on this task in their stride, there are many who would find it unmanageable. In the next chapter, we consider these and other drawbacks in more depth.

In the not-too-distant future, intensive longitudinal methods will be used not just for the assessment of everyday experience but also for momentary intervention. For example, a certain constellation of negative affect scores could trigger prompts to address an impending behavioral problem relapse (e.g., cigarette smoking, alcohol drinking, binge eating). These applications are already being investigated by some research groups (e.g., Intille, 2012; Nusser, Intille, & Maitra, 2006) and such work is sure to increase with time.

1.4 GOALS FOR THIS BOOK AND INTENDED AUDIENCE

Despite the promise of intensive longitudinal methods, these methods raise a variety of important practical issues of design, measurement, analysis, and write-up. The purpose of this book is to provide basic guidance on these issues so that readers can plan, carry out, analyze, and publish their own intensive longitudinal studies. Thus, we attempt to provide a practical, self-contained guide for those interested in conducting intensive longitudinal studies to understand behavioral and social phenomena.

This book is geared toward faculty, postdoctoral fellows, and advanced graduate students in the biomedical and social sciences, whether or not they have previous experience with intensive longitudinal methods. For example, we believe the book will be of use to graduate students planning dissertation studies and faculty seeking grant support for their first intensive longitudinal study. For those who already have experience with intensive longitudinal methods, the book provides guidance on more advanced topics such as mediation, psychometrics, and power analysis.

1.5 ORGANIZATION OF THIS BOOK

The remainder of the book is organized into nine chapters. Chapter 2 covers types of designs and research questions including choosing a design appropriate to your research question. It also includes a brief review of the range of technologies available for collecting intensive longitudinal data. Chapter 3 discusses the conceptual and

methodological issues that arise when one wishes to study a within-subject process using intensive longitudinal designs. Chapter 3 is necessary before we move onto the more detailed data analysis chapters that form the remainder of the book.

Chapter 4, the first and most straightforward analysis chapter, is devoted to modeling the temporal form of a within-subject change process for continuous outcomes. Chapter 5 tackles the much more difficult goal of modeling causes and consequences of the change process, again for continuous outcomes. A particular challenge that surfaces in this chapter and resurfaces in future chapters is the need to separate within-subjects from between-subjects variability in key longitudinal predictors of interest. Chapter 6 describes how analyses of causal processes can be conducted with categorical outcomes. Chapter 7 is devoted to the psychometrics of intensive longitudinal assessments of psychological states.

The final three chapters of the book cover advanced topics. Chapter 8 addresses intensive longitudinal studies of dyads, studies that are growing in popularity in social, personality, and clinical psychology. Here the special challenge arises from the additional interdependence that comes from collecting data from partners in the same relationship. Chapter 9 tackles another difficult issue—assessing within-subjects mediation using intensive longitudinal data. Within-subjects mediation involves complexities that are absent from traditional between-subjects mediation and requires either a complicated restructuring of the data or the use of specialized software. Chapter 10, the final chapter, is on estimating power for intensive longitudinal studies. Conducting a power analysis is usually an essential task for those seeking grant support for intensive longitudinal research, but it presents a challenge because of the multiple sources of random variability in models of intensive longitudinal data.

Throughout the book, we use example datasets, all of which are available on the website for this book. Within many chapters, we provide syntax code pertaining to three popular statistical software programs: SPSS (version 19), SAS (version 9.3), and Mplus (version 6). This code, as well as corresponding code for HLM, Stata, and R, can also be found on the book's website. We encourage readers to

use the datasets and code to gain experience with data analysis prior to, or in parallel with, analyses of their own data.

1.6 RECOMMENDED READINGS

Bolger, N., Davis, A., & Rafaeli, E. (2003). Diary methods: Capturing life as it is lived. *Annual Review of Psychology, 54*, 579–616.

This article provides a review of diary designs, the research questions to which they can be applied, and the statistical models that permit one to answer each type of research question.

Mehl, M. R., & Conner, T. S. (Eds.). (2012). *Handbook of research methods for studying daily life*. New York: Guilford Press.

This first-of-its-kind handbook contains 36 chapters on research that is real-world, real-time, and within-subjects.

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