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Commentary: Ecology momentary assessment as a tool for understanding dynamic patterns in child and adolescent health and development – reflections on Russell and Gajos (2020)

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Introduction

Ecological momentary assessment (EMA) is a cluster of methods involving intense repeated sampling of recent or current experiences and behaviors as they occur in their natural environments over a relatively short period of time. Several excellent reviews in various subfields of psychology including affective, personality, clinical, and health have discussed EMA as a valuable methodological tool that overcomes some of the limits of traditional assessments and that allows for examination of both within- and between-person variations (e.g., Stone & Shiffman, 1994; Trull & Ebner-Priemer, 2013). In their review, Russell and Gajos describe studies that leverage EMA's strengths to discover unique insights about youth's mental and behavioral health, effectively demonstrating how EMA can deepen understanding of child and adolescent psychology and psychiatry. Here, we echo the sentiment that EMA holds great promise for furthering developmental psychopathology research by underscoring its utility for interrogating microdynamic patterns in youths' lives. We describe how EMA can be used to model three aspects of microdynamic patterns, illustrate the value of combining EMA with traditional methodologies, and propose the potential of leveraging extant EMA data using meta- and mega-analytic techniques.

EMA-afforded insights into dynamic characteristics and processes

Childhood and adolescence are characterized by changes in internal (e.g., biological, psychological, and behavioral) and external processes (e.g., family, peer, and school). These individual and contextual fluctuations are thought to interact with one another in reciprocal and adaptive ways that unfold, accrue, and vary across various units of time, ranging from relatively micro ones (e.g., minutes, hours, days), to relatively macro ones (e.g., years, decades). Notably, the fluctuations and interactions along micro timescales represent *dynamic characteristics and processes* that systematically change with development (Baltes et al., 2007; Ram & Gerstorf, 2009) and that have implications for both short- and long-term adaptations, health, and development (Sameroff, 2000). Thus, dynamic characteristics and processes are thought to be central components of more macro health and development (Ram & Gerstorf, 2009; Sameroff, 2000), and yet, traditional methods are limited in capturing them.

Traditional cross-sectional studies have relied on one-time behavioral tasks or on retrospective questionnaires that require participants to reconstruct, recall, and estimate across experiences and time, providing only a static view of development. Traditional multiwave longitudinal studies can capture changes; however, their assessment intervals typically span several months or years, and thus can only characterize trajectories of change across broad timeframes. By contrast, EMA affords modeling of the dynamic processes occurring over micro timescales that are hypothesized to contribute to childhood and adolescent health and development (Baltes et al., 2007). Below, we describe three microdynamic patterns that EMA can be used to model: fluctuations of a variable, intrapersonal processes situated in time, and interpersonal processes.

Fluctuations of an attribute or experience

EMA can be used to characterize the extent to which a variable fluctuates across a defined micro time span, which is fundamentally distinct from its mean aggregated across the same micro time span. For example, two adolescents may exhibit identical mean levels of depressive symptoms across the past two weeks. However, they may differ in how their symptom levels are distributed over the two-week span: Whereas one adolescent's symptom levels may fluctuate widely from day-to-day over the two-week period, the other adolescent's symptom levels may be stable from day-to-day. An aggregated means approach would suggest that the two adolescents do not differ. In actuality, they differ vastly in how

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their means were reached. Using EMA, these dynamic fluctuations can be modeled as time-independent or as time-dependent variability—variability that is either tied or untied to temporal ordering—by computing indices such as intraindividual standard deviations, mean squared successive differences, and autocorrelations (Ram & Gerstorf, 2009). Characterizing how different individual and contextual attributes fluctuate over time may be important because fluctuations (or lack thereof) might meaningfully contribute to differential risk for certain outcomes (e.g., He et al., 2015).

Intrapersonal processes situated in time

EMA can also reveal insights about how youth's attributes, experiences, and environments covary with one another, as reviewed by Russell and Gajos. Importantly, youth's characteristics, experiences, and their interactions with internal and external stimuli are not isolated, but rather stringed together by time. Time itself is transitory, such that each fleeting moment (or other specified unit of time) is simultaneously history (relative to the following moment), present, and future (relative to the past moment). As such, an experience at any given time can impact subsequent experiences and be impacted by previous ones. EMA allows assessing of how a variable at one time point relates with another variable at a subsequent time point by estimating lagged associations. EMA can also interrogate more complex dynamics between youth's experiences and environments strung together by time in moderated lagged associations—for instance, a previous experience may interact with a current experience to predict a current or subsequent outcome.

Lagged and moderated lagged associations are important to examine because they may more closely reflect the relations and interactions between experiences at different micro timepoints that occur in reality. Furthermore, they may reflect processes conceptually different from concurrent associations—for example, concurrent associations may reflect youth's responses or reactivity to specific internal or external stimuli, whereas lagged associations may reflect recovery from, regulation of, or adaptations to those stimuli (e.g., Leger et al., 2018). Thus, (moderated) lagged associations can reveal how youth react to and recover from the internal and external demands they face in their everyday lives and how these adaptations are constantly impacting or interacting with one another. In turn, different patterns of temporal stringing may have different implications for development and risk.

Interpersonal processes

Lastly, EMA can deepen understanding of how youth's lives are interconnected with parents, peers, and other individuals in their environment. Notably, social relationships are made up of various dynamic interpersonal processes—verbal or nonverbal social transactions, interactions, exchanges—that transiently unravel and interact over moments, days, and weeks. These social transactions occur on micro timescales. Aggregated over time, however, they shape individual differences in the kinds of social relationship attributes that are typically assessed with traditional questionnaires or laboratory tasks. When administered to youth and other individuals in their environments, EMA enables gauging of these microlevel dynamic social transactions by modeling within-dyad associations between EMA child and other reports. This then allows examination of how youth's interactions with their close others or the experiences and behaviors of their close others can influence youth's health and development.

In particular, EMA can capture experiences that do not directly involve but nevertheless affect the youth. Parental experiences (e.g., stress at work) or mood states, for instance, can 'spill over' or transmit to youth presumably through parent–youth communications and behaviors. EMA can further capture nonverbal or implicit social exchanges, such as parental cognitive empathy—parent's accuracy in perceiving the youth's emotions. These spillover and empathic processes, in turn, can elicit responses in youth that have relevance for their health and functioning (e.g., Huynh et al., 2019). Importantly, these dynamic social processes are reciprocal in nature, and this reciprocity can be modeled with bidirectional concurrent and lagged associations between EMA parent and youth reports. That social contexts and relationships contribute to youth's health and development has long been recognized. EMA provides a lens into how social transactions in everyday lives—those explicit and implicit in nature and those that involve the youth directly or not at all—can have short-term impacts on youth that feed into health and development over the long-term.

Combining EMA with traditional methods

Central to developmental perspectives is the notion that human development happens on multiple timescales and that mechanisms for development and health eventuate through interactions of various dynamic processes within and between micro and macro timescales. EMA provides a window into dynamic changes as they unfold over various micro timescales. However, to determine how dynamic processes reflect mechanisms, how these vary between individuals and contexts, and how they in turn contribute to youth health and development, EMA may be most fruitful when administered in measurement-burst designs and combined with traditional assessments in longer-term longitudinal designs. To illustrate, we apply this mixed-methods approach to research on early adversity and health.

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Numerous theories about how early adversity impacts mental and physical health across the life span have been proposed and generally point to altered patterns of affective, cognitive, behavioral, and biological processes as key pathways that unfold, accumulate, and solidify over time. To test this, we might conduct a multiwave study that follows youth from 7th to 10th grade, with traditional assessments every 12 months wherein parent and youth would complete questionnaires or laboratory measures of health risks (e.g., low-grade inflammation), early adversity, individual differences (e.g., dispositional mindfulness), and contextual differences (e.g., neighborhood violence). Additionally, for two weeks every six months, parent and youth would complete nightly diaries about their experiences during the day (e.g., stressors, social interactions, affect, lifestyle behaviors) and wear actigraphy devices to assess their sleep and physical activity.

With this study, we could test theory-driven mediational scenarios. Specifically, we could examine whether early adversity assessed during 7th grade is prospectively linked with inflammation in 10th grade and whether this association is explained by 'unfolding' dynamics of social relationships, affective experiences, and lifestyle behaviors from 7th to 10th grade. For instance, fluctuation indices can be used to test whether early adversity disrupts the robustness of affect systems to promote inflammation. Likewise, various concurrent, lagged, and parent–child associations can be extracted from statistical models to determine whether, for example, stress-sleep connections or greater spillover of parents' work stress into their child's well-being operate as mediators. We can also determine how these dynamic mechanistic processes are moderated by broader individual and contextual factors: Are the observed indirect effects via affective and social dynamics attenuated among youth with greater dispositional mindfulness? Are they potentiated for youth living in neighborhoods with more crime and violence? Lastly, by tracking youth from 7th to 10th grade, the study covers pre-adolescence, early adolescence, and the beginning of mid-adolescence; and by administering EMA in repeated bursts, the study covers not only micro (day) and macro (year) timescales, but also an intermediary timescale (month). These features allow testing of whether daily processes fluctuate, intensify, or subside across early adolescent development, how daily processes build from micro to macro via intermediary timescales, and how these changes on multiple timescales affect health. For example, we can estimate how the day-to-day linkage between stress and sleep manifests within and between adolescent developmental stages and how those changes accelerate or decelerate inflammation trajectories.

This mixed-method approach can contribute to theory development and practice. Existing theories about mechanisms for how early adversity impacts lifelong health tend not to specify the dynamics of mechanistic processes over micro timescales. Yet, doing so importantly promotes more nuanced understanding of how fluctuations of characteristics, transactions with internal and external stimuli, and social exchanges in youth's everyday lives contribute to the accumulation of, as well as the continuity or discontinuity in, health risk. Additionally, many theories acknowledge that mechanistic processes may change across the life course, but do not specify the intricate dynamics occurring in intermediary timescales that crucially connect transitory processes to trait-like attributes. Practically, finer resolution in underlying processes can inform intervention and prevention efforts by revealing important target points—for example, minimizing variability and achieving stability may be more (or just as) important than reducing overall levels of a particular variable, or that improving parental accuracy of youth's daily affect is a critical target point for child's well-being.

Leveraging extant EMA studies

Despite the aforementioned advantages, the proposed mixed-methods study is highly resource-intensive and its analyses require large samples to attain sufficient statistical power. A complementary approach is to leverage existing EMA data using meta- and mega-analytical techniques. Whereas meta-analyses systematically and quantitatively synthesize existing literature on a particular phenomenon, mega-analyses (or integrative data analyses) combine multiple datasets with overlapping measures into a single dataset (Curran & Hussong, 2009).

As with primary analyses, both meta- and mega-analyses allow testing of dynamic processes as mechanisms, individual and contextual differences in those processes, and changes in them over more macro timescales. First, with respect to testing mechanisms, in meta-analyses, correlation matrices in literature on the associations between a postulated antecedent and mediator, mediator and outcome, and antecedent and outcome can be pooled together and then subjected to meta-analytic structural equation modeling to examine model fit and indirect effects (Cheung, 2015). In mega-analyses, measurement invariance and comparability are inspected, and measures are harmonized across datasets and then pooled into a single dataset on which indirect effect models can be estimated. Second, how dynamic processes along micro timescales and their mechanistic role differ by broader individual and contextual factors can be examined. More specifically, between-study heterogeneity in sample characteristics in meta-analyses and

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harmonized overlapping individual-level measures in mega-analyses can be leveraged to conduct moderator analyses of simple or indirect effects. Lastly, meta- and mega-analyses can examine how these dynamic processes might change over broader timescales, which can be challenging for primary data collection. For instance, to cover the course of both childhood and adolescence, primary data collection would have to either employ within-individual longitudinal designs that may take up to two decades to complete or employ between-individual designs that require a large sample to ensure sufficient cell size for each age group. However, capitalizing on between-study heterogeneity in developmental stage or age in meta- or mega-analyses affords a more time-efficient means for addressing this question.

Beyond addressing questions about youth health and development, meta- and mega-analyses can empirically inform future EMA study designs. Leveraging between-study variation in methodological characteristics, moderator analyses can reveal phenomenon-specific optimal sampling designs (e.g., interval contingent vs. signal-contingent), assessment frequency (e.g., hourly vs. daily), and assessment length (e.g., across one vs. 2 weeks). With little theoretical and empirical bases, these aspects of EMA design are often challenging to determine. Yet, EMA's extent of improving ecological validity is commensurate with the extent to which EMA sampling plans capture real-world signals, making it critical to delineate optimal study designs for each phenomenon of interest.

Meta- and mega-analyses, however, present their own set of challenges. For example, meta-analytic approaches are at the mercy of publication bias and the lack of individual-level data may lead to testing study-level moderators that actually vary at the individual-level in the real world (e.g., using sample's mean age vs. age). Both of these can introduce noise to results. In mega-analyses, between-study heterogeneity in measurement and design can make it extremely challenging to integrate studies without compromising the reliability and validity of the measures and thus results. Therefore, although these approaches are a more cost- and time-efficient means for addressing some aforementioned mechanistic and temporal questions, they are complementary to, and do not replace, primary data collection.

Conclusion

Child and adolescent health and development do not passively unfold along predestined courses; rather, they are constructed by experiential moments that, at any given time, can change the person, their path, and their destination. EMA critically allows a window into the complex dynamics in these moments of youth's everyday lives. When integrated with traditional assessments, longitudinal designs, and measurement bursts in primary data collection, and when integrated across extant studies in meta- and mega-analytic approaches, EMA can crucially reveal the dynamic fluctuations, intrapersonal processes, and interpersonal transactions that underlie developmental or psychopathological phenomena in children and adolescents.

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