# Ecological Interventionist Causal Models in Psychosis: Targeting Psychological Mechanisms in Daily Life

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Integrated models of psychotic disorders have posited a number of putative psychological mechanisms that may contribute to the development of psychotic symptoms, but it is only recently that a modest amount of experience sampling research has provided evidence on their role in daily life, outside the research laboratory. A number of methodological challenges remain in evaluating specificity of potential causal links between a given psychological mechanism and psychosis outcomes in a systematic fashion, capitalizing on longitudinal data to investigate temporal ordering. In this article, we argue for testing ecological interventionist causal models that draw on real world and real-time delivered, ecological momentary interventions for generating evidence on several causal criteria (association, time order, and direction/sole plausibility) under real-world conditions, while maximizing generalizability to social contexts and experiences in heterogeneous populations. Specifically, this approach tests whether ecological momentary interventions can (1) modify a putative mechanism and (2) produce changes in the mechanism that lead to sustainable changes in intended psychosis outcomes in individuals' daily lives. Future research using this approach will provide translational evidence on the active ingredients of mobile health and in-person interventions that promote sustained effectiveness of ecological momentary interventions and, thereby, contribute to ongoing efforts that seek to enhance effectiveness of psychological interventions under real-world conditions.

*Key words:* schizophrenia/ecological momentary intervention/experience sampling methodology/causal criteria/psychological intervention

## Introduction

Recent years have seen a move toward integrated models of the etiology of psychotic disorders[1–4] that consider not only the impact (and interplay) of biological and socioenvironmental factors but also posit a number of putative psychological mechanisms that may contribute to the development or exacerbation of psychosis.[1–11] To date, these mechanisms have been primarily studied in the research laboratory using cross-sectional or experimental designs, and in relation to specific symptom dimensions (ie, positive symptoms, negative symptoms, disorganization, mania, and depression[5,6,11]) or specific symptom types (eg, hallucinations, delusions).[1,6,7,12] It is only recently that, through a series of studies using experience sampling methodology[13] (ESM; or, synonymously, ecological momentary assessment (EMA)[14,15]), we are beginning to understand the role of these putative psychological mechanisms in daily life, outside the research laboratory. ESM is a structured diary technique that allows for frequently repeated, naturalistic sampling of thoughts, feelings, and behavior experienced in the moment, nowadays typically accomplished through mobile devices.[13–15] Experience sampling studies explicitly acknowledge, and purposefully seek to elucidate, the dynamic nature of psychological processes over time, harnessing the ESM's unique advantage of capturing moment-to-moment variation in psychological processes through multiple assessments in the real world.[13–15] The ESM further allows to study the impact of, and individuals' interaction with, the microenvironment and, thereby more generally addresses calls for investigating more proximal, microlevel (rather than distal, macrolevel) environmental risks in the occurrence and persistence of psychosis.[13,16]

## Putative Psychological Mechanisms in the Development and Exacerbation of Psychosis in Daily Life

Most experience sampling studies conducted to date have investigated stress sensitivity, characterized by increased emotional reactions to minor stressors and routine daily hassles, as a putative psychological mechanism in the development or exacerbation of psychotic symptoms in daily life using time-based designs with stratified (semi) random time sampling (ie, with ESM assessments scheduled at random or semirandom moments within set blocks of time).[13,15] A number of studies have reported elevated emotional reactivity to minor stressful events, activities, and social situations in individuals with enduring psychosis and in those with higher familial or psychometric risk.[17–21] Two studies in individuals at ultra high-risk (UHR) of developing psychosis,[22,23] reported greater emotional reactivity to minor activity-related and social stress in this group.[24,25] Findings from the only study conducted to date in individuals with first-episode psychosis (FEP),[25] which allowed to minimize the impact of illness chronicity,[20,24] further suggests that elevated stress sensitivity is associated with an increased intensity of psychotic experiences in FEP individuals, UHR individuals and controls, and this association is greatest in FEP individuals. In patients with psychotic disorder, stress sensitivity has also been specifically associated with positive symptoms of psychosis.[26] Furthermore, it has been demonstrated that individuals with a psychotic disorder show increased reactivity to positive events happening to them.[27] Specifically, they reported increased positive affect when a pleasant event was happening, suggesting an overall increased sensitivity to the environment, either positive or negative.

Experience sampling studies have considered the role of emotional and social experience in negative symptoms of schizophrenia in daily life.[27–33] Findings from these studies suggest that, surprisingly, deficits in expression and blunted affect in individuals with psychotic disorder are not associated with a reduced intensity of emotional experience in daily life.[30,31,33] However, individuals with schizophrenia and high negative symptoms have been found to show a stronger preference for being alone when in company and more social withdrawal in daily life.[27] Similarly, there is evidence of a greater preference for solitude, increased time alone, and lower positive affect in the daily life of individuals with subclinical social anhedonia.[28] While experience sampling studies have reported fewer goal-directed activities in individuals with schizophrenia, findings on a diminished effort in pursuit of complex goals in daily life remain equivocal.[31,32]

Other putative psychological mechanisms that have been investigated using ESM include cognitive self-consciousness,[34] meta-cognitive beliefs,[34,35] self-esteem,[35–37] coping,[38] self-management strategies,[39,40] cognitive appraisal,[41] affective disturbance,[42,43] enhanced threat anticipation,[25] experiences of aberrant novelty and salience,[25] and their association with psychotic experiences. Taken together, ESM is an innovative method that has significantly improved our understanding of the association between a number of putative psychological mechanisms and psychotic experiences. However, notably, the number of experience sampling studies on putative psychological mechanisms that may contribute to the development of psychosis remain modest and have primarily been conducted in samples of patients with enduring psychotic disorder or individuals with increased familial or psychometric risk. Also, direct replication of findings using identical methodology across samples is rare and the role of a number of putative psychological mechanisms (eg, reasoning and attributional biases)[1] proposed by contemporary models of psychosis remain to be investigated in daily life. However, probably the most important caveat of experience sampling research to date is that most studies used cross-sectional modeling without taking advantage of the longitudinal structure of ESM data. Hence, while the modest number of experience sampling studies conducted thus far suggests that there is an *association* between a number of potentially relevant psychological processes and psychotic experiences, the available evidence does not allow for any firm conclusions to be drawn as to whether there is a causal link between these psychological processes and the development of psychotic experiences.

## Targeting Putative Psychological Mechanisms in Daily Life: An Ecological Interventionist Causal Model Approach

While to date there is no consensus on the precise definition of what constitutes a "cause" or "causation", several criteria have been proposed by epidemiologists as guidelines for evaluating causal inferences.[44] These criteria may be, as Schwartz and Susser[44] have pointed out, of particular value in the planning stages of a study for evaluating the strength and consistency of the current evidence, based on all previous research[44,45] (rather than for evaluating the results at the end of a single study). Consistent with Susser,[46] their essential properties have been held to be: "association" (between putative mechanism and psychosis outcome; enhanced by strength and consistency), "time order" (ie, the putative mechanism precedes psychosis outcome), and "direction" (ie, a change in the putative mechanism leads to a change in the outcome),[46] also referred to as "sole plausibility" (ie, elimination of any remaining plausible explanation for the association).[44] While these key criteria explicitly acknowledge that causality cannot simply be operationalized as a binary concept (of presence or absence of causality) and primarily refer to (and may be best utilized for optimizing) the internal validity of a given study, it also needs to be established under what circumstances a

putative causal mechanism has an effect on the outcome (external validity).

At the same time, recent years have seen calls for interventionist causal models for evaluating causal claims in psychiatry.[47,48] Central to defining causation in these models is the question "...of what would happen under interventions" (Kendler and Campbell,[47] p. 881), thereby taking the key practical interest of psychiatry into account, ie, to intervene, treat or prevent illness.[47] Freeman[48] has recently advocated an interventionist causal model approach for improving cognitive treatments for delusions. This approach adopts a strategy that: (i) targets one specific causal factor at a time; (ii) shows that an intervention can change it; and (iii) examines the subsequent effects on delusional beliefs.[48]

Real-time and real-world assessment (ie, ESM) and interventions (ie, ecological momentary interventions) may fundamentally contribute to and enhance such an interventionist causal model approach.

An essential first step in this approach is the assessment of the psychological mechanism and psychosis outcome, which we have already argued ESM can contribute to by capturing psychological processes in interaction with the proximal, microlevel environment. Second, drawing on the above causal criteria, it needs to be shown that the putative causal mechanism precedes the outcome of psychotic experiences (and not vice versa) in daily life for establishing time order (see figure 1). Intensive longitudinal assessments obtained in the real world with ESM are perfectly fit to capture and test this temporal order (using lagged analyses). However, this does still not rule out that there is an alternative explanation of the association between the putative mechanism and psychosis outcome, or, in other words, a common underlying factor that causes the putative mechanism on the one hand and psychotic experiences on the other (ie, evidence of direction or sole plausibility). Therefore, an ecological interventionist causal model approach moves beyond investigating temporal order in an observational design, by targeting the putative psychological mechanism to investigate whether changes in the psychological

mechanisms ultimately result in changes in the symptoms they are supposed to be causing.

Leveraging the immense processing power of mobile devices, a variety of studies have utilized real-time data to scaffold targeted psychological interventions. As psychological mechanisms are dynamic processes affected by, and interacting with, the microlevel environment, the effectiveness of any intervention targeting mechanisms is likely to be greater if delivered in real life, outside the clinician's office. These real-world and real-life interventions, now commonly referred to as ecological momentary interventions,[14,49] may be particularly useful for testing causal criteria under real-world conditions. The ecological interventionist causal model approach thus targets the putative psychological mechanism *in daily life* to test whether an ecological momentary intervention can (i) modify this mechanism and (ii) produce changes in the mechanism that lead to changes in intended psychosis outcomes (ie, whether the effect of an ecological momentary intervention on psychotic symptoms is mediated via pathways through this mechanism)[50] (see figure 1). Such interventions could be scalable given the ubiquity of mobile devices, and thus corresponds to calls for research that identifies mechanisms in clinical trials,[51] provides the best evidence to relevant clinical problems of everyday practice,[52] which is generalizable to both social contexts in the real world[13,53–55] and heterogeneous patient populations across the transdiagnostic psychosis disorder spectrum,[56,57] and informs the service user as well as clinician perspective.[58–61]

The benefits of such an ecological interventionist causal model approach are at least 2-fold. First of all, this approach allows for generating evidence on several causal criteria simultaneously, including association, time order, and direction/sole plausibility (all contributing to internal validity), while being explicitly *pragmatic* in nature, with the goal of optimizing generalizability of findings to both real-world contexts (outside the research laboratory) and heterogeneous populations, contributing to external validity. Second, it is *translational* in that it provides robust evidence whether the ecological momentary
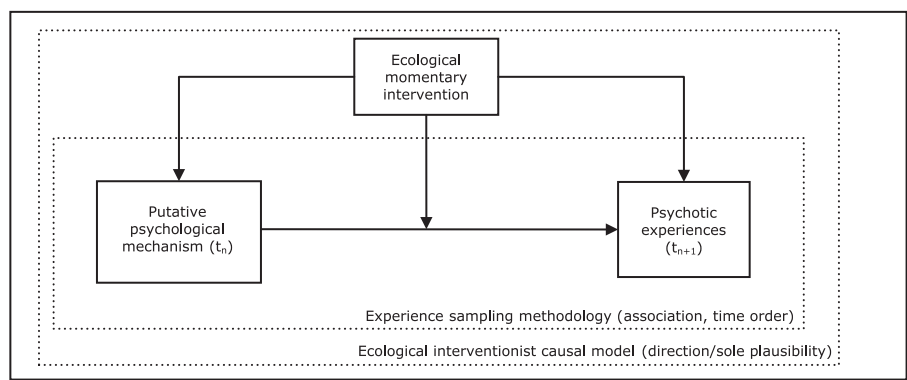


**Fig. 1.** Targeting psychological mechanisms in daily life: an ecological interventionist causal model approach.

intervention is an effective treatment for reducing psychotic experiences in daily life.[48] This approach will, thereby, contribute to ongoing efforts that seek to enhance effectiveness of psychological interventions under real-world conditions.[52,56,62–64] A key distinction in intervention development is that ecological causal momentary interventions strive for *sustainable change* rather than *compensation* for deficits. For example, an intervention designed to promote medication adherence might deliver targeted reminders to accommodate for memory deficits, whereas an ecological causal interventionist approach would target the social-contextual factors and beliefs about medications that increase risk of poor adherence. The latter approach would theoretically generate more lasting changes in medication adherence behavior that limit the degree to which mobile interventions would be needed in perpetuity. Given that ecological momentary interventions for chronic illnesses, as with e-health approaches and in-person therapies, generally have diminishing engagement over time,[65,66] targeting mechanisms that will generate sustained changes after cessation of engagement with the intervention maximizes the potential impact.

## Testing Ecological Interventionist Causal Models in Psychotic Disorders

To date, ecological momentary interventions for psychosis spectrum disorders have been largely evaluated in uncontrolled "proof-of-concept" studies and mechanistic hypotheses have not been tested. Granholm et al[67] evaluated a text-messaging approach to targeting maladaptive beliefs corresponding to 3 outcomes, socialization, medication adherence, and voices. Findings indicated changes in maladaptive beliefs (eg, perceptions of lack of control over voices) related to changes in outcomes (eg, perceived distress about voices).[67] Ben-Zeev et al[68] evaluated a smartphone-based system with similar targets, but with user-driven interaction. Further, Steinhart et al[69] have developed and are currently evaluating the effectiveness of an ecological momentary intervention that targets elevated stress sensitivity, altered reward-experience, and psychological flexibility based on principles of acceptance and commitment therapy (ACT) in UHR individuals. This ongoing ACT in daily life study extends standard ACT therapy with real life training and exercises through a dedicated device (ie, the PsyMate®), thereby enhancing participants' ACT-based skills and techniques. It remains to be demonstrated whether this approach indeed is effectively reducing symptoms through altering stress sensitivity, reward-experience, and psychological flexibility. Further highlighting the need for causal interventionist models, in one of only ecological momentary randomized controlled trials to include a follow up assessment, Depp et al[39] evaluated an ecological momentary intervention that delivered real-time targeted coping strategies mapped to specific illness states. Although depressive symptoms declined substantially more in the ecological momentary intervention group compared to an active control group, this separation was minimal 3 months after intervention participation had stopped. One takeaway from this clinical trial was that perhaps intervention content focused on the psychological mechanisms that create vulnerabilities illnesses states (rather than adaptive means of managing those states) may have sustained the intervention impact consistent with the approach described in this article.

## Conclusion and Future Prospects

Although putative psychological mechanisms that may contribute to the development or exacerbation of psychotic experiences have been investigated for decades, it is only recently that a modest amount of experience sampling research has provided evidence on their role in daily life, outside the research laboratory. A number of methodological challenges remain in validating psychological mechanistic theories in a systematic fashion, capitalizing on longitudinal data to test temporal ordering, and evaluating specificity of potential causal links between a given psychological mechanism and psychosis outcomes under real-world conditions. We have argued here for testing ecological interventionist causal models that allow for generating evidence on several causal criteria simultaneously (association, time order, and direction/sole plausibility), while maximizing generalizability to heterogeneous populations and social contexts. Future research using this approach will further provide translational evidence on the active ingredients of mobile health and in-person interventions that promote sustained effectiveness of ecological momentary interventions and, thereby, contribute to ongoing efforts that seek to enhance effectiveness of psychological interventions under real-world conditions.

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