Ecological Momentary Assessments: A Contextual Behavioral Approach to Studying Mindfulness and Acceptance in Psychosis

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The purpose of this chapter is to explore the role of assessment from a contextual behavioral science (CBS) perspective. We argue that a more contextual assessment of environmental and behavioral variables is key for the treatment of severe psychopathology. In line with one of the premises of the CBS approach, the development of rules of generalization with precision, scope and depth, we argue that the ecological momentary assessment method (EMA) improves the precision of standard assessment strategies, which will help us understand the contextual behavioral etiology of these disorders. This chapter also presents a brief description of the development of acceptance and mindfulness-based EMA items, discusses the integration of behavioral science and computer science to enhance assessments in this population, and finally illustrates the advantages of the EMA method in a patient diagnosed with paranoid schizophrenia.

Keywords: contextual behavioral science, severe psychopathology, precision, ecological momentary assessments, computer science, mobile technology.

Why contextual behavioral assessment methods?

Context matters

Effective clinical behavior change begins with an assessment of an individual's context. An individual's context usually contains directly manipulable variables that can inform effective behavior change, such as levels of activity, relationship patterns, or self-regulation strategies. This emphasis on context is the foundation of the contextual behavioral science tradition (CBS; Hayes, Hayes, Reese, & Sarbin, 1993; Vilardaga, Hayes, Levin, & Muto, 2009), for which context includes not only an individual's current situation, but also how that situation unfolds over time. In other words, context includes both the situational and historical factors influencing an individual's behavior.

In severe psychopathology (i.e., schizophrenia spectrum, bipolar and recurrent major depressive disorder), context may include a variety of factors: a history of childhood sexual abuse or trauma (Honig et al., 1998), stigmatization (Norman, Windell, Lynch, & Manchanda, 2011), or an unsupportive social environment (Norman et al., 2005). Other environmental factors, such as living in an urban or rural environment (McGrath, Saha, Chant, & Welham, 2008), living in a country with high levels of sugar intake (Peet, 2004), or prenatal influences (King, St-Hilaire, & Heidkamp, 2010; Walker, Shapiro, Esterberg, & Trotman, 2010) have also been associated with severe psychopathology. However, from a CBS standpoint, directly manipulable factors are most important. Talk therapy is directly manipulable and can be part of an individual's verbal context. For example, a history of exposure to cognitive behavior therapy, including training in self-regulation skills to cope with both private and environmental events, has been linked to positive outcomes in people with psychosis (Wykes, Steel, Everitt, & Tarrier, 2008).

All of these contextual factors can have a profound effect on behavior. Furthermore, behavior itself exerts an influence on the external context, in turn affecting the individual. A typical example is when individuals with psychotic symptoms believe their voices are threatening, and thus take steps to mitigate, distract from, or avoid situations in which the voices occurred in the past. As a consequence, social withdrawal may occur, providing these individuals with less access to social reinforcers.

Like any other living organism, individuals with severe psychopathology exert and are exerted upon by a multitude of contextual factors that unfold over time. Despite their complexity, these contexts can be sampled, examined and interpreted separately in order to develop interventions that lead to effective clinical behavior change.

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Aren't we already measuring context?

When a patient attends one of our sessions, we are always directly observing behavior in context. Through these routine observations we gather a variety of information critical to planning our interventions, such as what the patient thinks, feels and wants (e.g., current verbal and emotional context). We also gather more indirect information, such as the patient's reactions to our questions or repeated patterns of thinking, feeling and wanting (e.g., historical verbal and emotional context). Although these data can inform effective clinical behavior change, it is only a small fraction of our patient's historical and situational context. Furthermore, from the moment we ask one of our patients "how was your childhood?", "your last five years?", or "your last week?", we are entering the realm of recall bias and interpretation.

Clinical behavioral sciences have experienced a lack of appropriate contextual measurement tools nearly from their inception. Direct access to an individual's context was critical for early behavior therapists, since it provided the ability to deliver direct contingencies (Dougher & Dougher, 2000). Fields such as school, developmental, and organizational psychology often have access to an individual's context. However, such access to direct contingencies was not always possible or feasible, resulting in a number of consequences. For one, it hindered the progress of clinical behavioral science by undermining its ability to identify and target powerful independent variables leading to desired outcomes. For example, the results of experimental research conducted in laboratories could not be contextually validated in natural settings, which justified the mere use of interpretation and extrapolation of behavioral principles (Vilardaga et al., 2009). Second, this problem contributed to the low scientific status of clinical behavioral science within the larger scientific community, since measures were primarily based on global self-reports. Third, clinical behavioral researchers increasingly relied on measurement instruments rooted on essentialist philosophical assumptions about the nature of human behavior (e.g., underlying traits), which justified the use of global measurement tools, such as global self-report scales or personality tests.

Up until today, the vast majority of the empirical literature in clinical psychology relies on the use of global self-report measures, direct observation (e.g., one hour, once a week), or collateral reports. Even though global self-reports are a very practical method of gathering information about an individual's context, they have serious limitations. In clinical practice we typically find patients describing their week as "bad" because some negative events occurred the day before, regardless of having experienced prior days positively. In fact, research has found that global self-reports are biased towards more recent events (e.g. Sato & Kawahara, 2011).

The limitations of global self-report strategies do not have to lead to an "either/or" solution. Global self-reports and clinical observation are important sources of data. These assessment tools can point to specific contexts, response patterns, and events. However, they are very limited evaluating the intricate sequence of events that occur on a daily basis, and they lack the *precision* of contextual behavioral research conducted in the laboratory (e.g., Hughes, Barnes-Holmes, & Vahey, 2012). Consequently, these measurement tools have serious limitations in their capacity to establish meaningful and data-rich connections among context, life events and individuals' responses to them in real-world settings.

Current assessment strategies are not adequate for adults with severe psychopathology

Global self-report measures and interview data are particularly problematic among individuals with severe psychopathology. When measured by performance in neuropsychological tests, many individuals with severe psychopathology have deficits in attention, concentration, working memory, processing speed and problem solving skills (Dickinson, Iannone, Wilk, & Gold, 2004; Elvevåg & Goldberg, 2000; Harvey, 2010). Studies suggest that these deficits cannot be pinned down to specific cognitive abilities (Dickinson et al., 2004; Keefe et al., 2006) and they tend to be stable over time (Rund, 1998). Cognitive deficits inevitably have an effect on the ability of individuals with severe psychopathology to process and report their experiences.

The cognitive deficits observed in severe psychopathology are associated with poor functional outcomes in this population (Harvey, 2010; Harvey et al., 1998), such as difficulties with work, poor interpersonal skills, and lack of engagement in community activities (Bowie et al., 2008). These deficits often escape individuals' self-awareness, as studies show that the results of formal cognitive tests have little to no association with individuals' perceived levels of disability in this population (McKibbin, Patterson, & Jeste, 2004).

More directly related to the area of assessment, poor reporting among individuals with severe psychopathology leads to bad clinical decision making, medical errors, and difficulties conducting a clinically useful functional analysis. Studies of service utilization found that client self-report responses were a poor predictor of visits on record in this population. Low utilizers tended to overstate their number of visits, and high utilizers tended to understate them (Kashner, Suppes, Rush, & Altshuler, 1999). Another study by Calsyn, Morse, Klinkenberg, and Trusty (1997) found little agreement between reports by clients with severe psychopathology and case managers regarding type and amount of mental health and substance abuse services utilized. Additionally, adults with severe psychopathology and a physical illness demonstrated less knowledge of their health condition when compared to adults in the general population with the same physical illness (Dickerson et al., 2005; Hinkin et al., 2002; McKinnon, Cournos, Sugden, Guido, & Herman, 1996). Poor self-report can also misdirect therapy, in that the intensity of negative and positive daily experiences of individuals with severe psychopathology may be magnified retrospectively (Ben-Zeev, McHugo, Xie, Dobbins, & Young, 2012). Among clinically depressed patients, Ben-Zeev, Young, and Madsen (2009) found negative affect to be particularly emphasized in retrospect. The overestimation of the intensity of such experiences makes it difficult to accurately compute the variability of a patient's experience over the recall period. Since retrospective reporting may also be used to inform medication choice, experiences that are overestimated in their intensity may result in unnecessary prescription or increased dosage of medications with potentially unpleasant side effects (Ben-Zeev et al., 2012).

The prevalence of cognitive deficits in individuals with severe psychopathology together with the limitations of global self-report tools to measure clinically relevant features of the individual's context, warrant the use of measurement tools that are sensitive to a broader range of contextual and environmental factors and less reliant on an individual's ability to retrospectively recall past events and circumstances. Such method, called ecological momentary assessment, consists in asking participants to take a moment several times per day to report on their own experiences in real time (Csikszentmihalyi & Larson, 1987). EMAs (also known as the experience sampling method), have been in use for a few decades now.

Affinity of EMAs to the contextual behavioral tradition

From a contextual behavioral perspective, psychological events are under the control of a unique set of contextual antecedents and consequences. The combination of antecedents, behaviors and consequences form a more meaningful unit than traditionally "decontextualized" measures (e.g., global self-reports), in which individual's responses are gathered in the vacuum of a laboratory or artificial setting. EMAs can collect, for each measurement instance, the specific external context (e.g., being alone), internal context (e.g., a psychotic event), the individual's psychological response to them (e.g., acceptance), and a measure of the following consequences (e.g., affect). This method of assessment circumvents the memory bias that comes with the "skewed averaging" of experience that typically occurs when we are asked to provide a global evaluation of our day or week.

In science, as well as in clinical practice, measurement is important, as good scientific theories require *precision* as well as scope and depth (Hayes et al., 1993). The small but critical improvements in the quality of the data collected by EMAs can help contextual behavioral researchers examine rules of generalization (e.g., principles of change) with increased levels of *precision*. Furthermore EMAs provide not only better measurement precision but soon new mobile devices will be able to measure the impact of behavioral interventions at different levels of *depth* (e.g., physiological states; Kimhy, Sloan, Delespaul, & Malaspina, 2006). In the long run, this may dramatically improve the contextual behavioral etiology of severe psychopathology by clarifying the psychological processes promoting overall functioning and quality of life in this population. This excitement seems to have contributed to the rapid proliferation of EMA research, since the field has experienced an exponential growth of studies of this nature (e.g. Ben-Zeev, 2012; Kimhy, Myin-Germeys, Palmier-Claus, & Swendsen, 2012; Oorschot, Lataster, Thewissen, Wichers, & Myin-Germeys, 2012; Shiffman, Stone, & Hufford, 2008).

Another affinity of the EMA method with CBS is its challenging of traditional views with regards to measurement development. Most statistical and psychometric theory starts off with the assumption that there is a "latent structure" underlying psychological constructs that represents a stable quality of behavior that can be captured. This statistical assumption is contrary to the contextual behavioral tradition, for which psychological events can only be understood in context, and for which "truth" lies in pragmatic utility and not in correspondence with a stable "latent structure" or reality (Vilardaga et al., 2009). For example, from a CBS standpoint, the term "acceptance" is a verbal construct that orients the listener (in this case a researcher or clinician) towards behaviors linked to general functioning. However, there is no assumption about the stability of these patterns of behavior, as these behaviors can fluctuate according to varying sequences of antecedents and consequences. In fact, EMA developers have noted that this method is theoretically consistent with the behavioral tradition (Hektner, Schmidt, & Csikszentmihalyi, 2007), as the emphasis is placed on the identification of key environmental elements underlying psychological states.

If we assume the utility of this new framework, psychometrics plays a secondary role in the development of EMA items from a CBS perspective. Having put psychometric theory aside, we are left with important study design criteria, such as theoretical coherence and appropriate survey design. For example, Kimhy et al. (2012) argued that it is important to present more cognitively demanding items (e.g., questions about internal state) at the beginning of a survey and simpler items towards the end. Similarly, items should only address one construct at a time and use sentences that are easy to comprehend (Kimhy et al., 2012). Interestingly, these principles are seen in user-centered design (Fairbanks & Caplan, 2004). Although this concept was not explicitly formulated in early EMA studies, their designs were driven by the very same sensitivity. Therefore, relevant issues when it comes to selecting and adapting EMA items are acceptability, wordings that are user-friendly, assessment burden or appropriate conditional branching. Surveys can also be branched so that specific items can only be triggered when certain conditions are met (e.g., being alone). For a more thorough description of theoretical, technical and design considerations of EMA designs we recommend Hektner's book-length volume (Hektner et al., 2007). A more contemporary description of the design of computerized EMA studies for adults with severe psychopathology can be found in Kimhy et al. (2012).

Despite the fact that EMAs pose a new approach to item development and formulation and that the measurement of momentary patterns of behavior and psychological states is inherently unreliable (Hektner et al., 2007), EMAs arguably have a number of psychometric advantages over traditional assessment methods. For example, EMAs provide measurements of high external validity, since they gather data directly from real-world settings. In addition, EMAs might provide more internal validity than global self-report measures, since repeated measurements avoid the bias of one-time reports, and minimize the likelihood of a social desirability bias (Zuzanek, 1999). Finally, random sampling of surveys throughout the day provides a more representative sample of experiences than traditional global self-report measures (Hektner et al., 2007).

On the whole, researchers have found EMAs to be a rigorous approach to collecting data in this population and have been recommended in light of the limitations of current clinical and performance measures available in the field (Granholm, Loh, & Swendsen, 2008). Furthermore, some authors suggest that ecological momentary assessments could be considered the new "gold standard" given their high concurrent validity with traditional clinic-based measures and high levels of compliance (Kimhy et al., 2012).

Brief review of existing contextual behavioral assessment research in severe psychopathology

Contextual behavioral assessments using EMAs have been developed by researchers for a few decades now (Csikszentmihalyi & Larson, 1987; Csikzentmihalyi, Larson, & Prescott, 1977) and have been argued to have higher ecological validity than traditional global self-report methods (Shiffman et al., 2008; Wenze & Miller, 2010). Surprisingly, within the CBS community, there are still very few studies taking advantage of this assessment approach. In this section we will describe studies using EMAs with a focus on individuals with severe psychopathology.

Review of EMA studies in Psychosis

The first EMA researchers in the area of psychosis used pagers or programmable watches to signal the use of a booklet with a series of questions about the individual's current activity and experience (Delespaul & deVries, 1987). These prompts had to be answered within 15 minutes and were provided during a period of 6 days. Researchers found that in this population social activities were enjoyed as much as in the general population. However, individuals with severe psychopathology had a tendency to daydream and distract from current activities while alone. The kind of thoughts and activities that the clinical sample engaged in were no different than those of the non-clinical group, but their mental states (e.g., mood, motivation) were significantly worse. The authors also observed that although both groups of individuals had similar levels of fluctuation in their mental states, the clinical sample had greater reactivity to daily events.

Using a similar procedure, deVries and Delespaul (1989) studied a sample of patients with schizophrenia in comparison to normal subjects, and found that the relationship between positive affect and being alone was curvilinear in nature: being in the presence of up to three individuals was associated with greater positive affect. However, being in the presence of more than three individuals was associated with a decline in positive affect. Conversely, the relationship between positive affect and social context was almost linear among normal subjects. Some of the items utilized in this study are presented in Table 1.

EMAs have also been used to explore and refine specific psychological models. For example, according to the self-esteem model, individuals experience paranoid ideation as a defense against negative thoughts and emotions towards the self (Bentall, Corcoran, Howard, Blackwood, & Kinderman, 2001). However Thewissen et al. (2008) found that negative emotions, in particular anxiety, can also lead to paranoia. Another EMA study by Lardinois et al. (2007) suggested that developing a conscious appraisal of the distress of psychotic events and the use of coping strategies might be beneficial to patients with psychosis. Verdoux and colleagues (2003) found evidence against the self-medication hypothesis by showing that cannabis use preceded psychotic symptoms and not viceversa among individuals with high levels of social anhedonia. The intensity of the emotional experiences is similar across individuals with and without a psychotic disorder (Myin-Germeys, Delespaul, & deVries, 2000). Similarly, consummatory pleasure (e.g., the enjoyment directly drawn from immediate experiences) was similar between patients with psychotic symptoms and normal controls. However, anticipatory pleasure (e.g., the anticipated enjoyment drawn from future activities) was lacking among clinical samples, as they engaged in less EMA measured goal-directed activities (Gard, Kring, Gard, Horan, & Green, 2007). With regards to reactivity to daily life events, Myin-Germeys et al. (2003) found that this relationship was moderated by cognitive ability, and in a separate study, the same authors found that social context, such as the presence of family or acquaintances, reduced the likelihood of experiencing a delusional experience at a later time (Myin-Germeys, Nicolson, & Delespaul, 2001).

Researchers have also conducted EMA studies to look at issues such as personality disorders (Loewenstein, Hamilton,

Table 1
Examples of EMA Items used in the literature to assess psychotic symptoms

deVries & Delespaul, 1989; *(7-point Likert scale)*	
"I hear voices" "I cannot express my thoughts" "I feel unreal"	"I'm suspicious" "My thoughts are influenced" "I can't get rid of my thoughts "
Junginger et al., 1992; *(7-point Likert scale)*	
"I'm preoccupied by my thoughts right now" "My thoughts are being influenced"	"My thoughts are suspicious"
Myin-Germeys et al., 2005; *(7-point Likert scale)*	
"Do you hear voices?"	"Do you see things that others cannot see?"
Kimhy et al., 2006; *(7-point Likert scale)*	
"I see things (that other people can't see)" "My thoughts are suspicious" "I can't get rid of my thoughts" "I feel unreal" "This thought is confused"	"I hear voices (that other people can't hear)" "I'm in control of my thoughts" "I fear I would lose control" "My thoughts are difficult to express"
Granholm et al., 2008; *(7-point Likert scale)*	
Since the last questionnaire: "Have you had the impression that someone was spying on you or plotting against you?" "Have you had the impression that people could read your thoughts, or that you could read theirs?" "Have you felt you were possessed or that someone or something was putting thoughts into your mind?" "Have you felt that someone could communicate with you through the television or radio?" "Did you feel you had special powers to do something nobody else can do?" "Have you heard things (such as voices), had visions, or seen things that others could not see or hear?"	

Alagna, Reid, & deVries, 1987), mood and anxiety (Junginger, Barker, & Coe, 1992; Swendsen, 1997), and substance abuse (Collins et al., 1998; Freedman, Lester, McNamara, Milby, & Schumacher, 2006). Table 2 summarizes some of the items used to assess mental states, such as cognition, affect and general well-being. A list of EMA items assessing situational context can be found in Table 3. This table shows examples of different items used by researchers over the years. Among all the EMA studies reviewed, only two explored the impact of acceptance and mindfulness-based processes on the occurrence of psychotic symptoms (Udachina et al., 2009; Varese, Udachina, Myin-Germeys, Oorschot, & Bentall, 2011, see description below).

In summary, EMAs have great potential to test specific hypotheses about the contextual behavioral etiology of symptoms in severe psychopathology as well as provide a more precise measure of the effect of specific environmental factors and/or interventions.

Computerization of EMA studies. While we will address the computerization of EMAs in later sections, handheld computers such as Portable Digital Assistants (e.g., Palm pilots) or cell phones with software capacity have increasingly been adopted by researchers. Computerized EMAs can measure and collect data in ways that offer many advantages with respect to paper and pencil diaries (Ben-Zeev et al., 2012; Granholm et al., 2008). Some of them include the stamping of data with the time and date of collection, potential to collect response time, easy transfer of data to analytic software to be readily analyzed, and the possibility of programming conditional rules upon specific answers (i.e., branching). Despite the functional impairment typically observed among individuals with severe psychopathology, the use of computerized EMAs has been shown to be equally feasible to paper and pencil EMAs (e.g., Granholm et al., 2008; Kimhy, Delespaul, et al., 2006), and nowadays, most studies make use of these devices.

Studies examining acceptance and mindfulness-based processes using EMAs

To our knowledge, only a handful of studies have explored acceptance and mindfulness-based processes using EMA to investigate psychotic symptoms, and only two used EMAs directly with individuals with severe psychopathology. Varese et al. (2011) conducted a study in which EMAs were used to examine the occurrence of auditory hallucina-

Table 2
Examples of EMA Items used in the literature to assess psychological states

Delespaul et al., 1987; *(7-point Likert scale)*	
About the thoughts	*About mood*
"I am alone"	"Cheerful"
'Pleasant"	"Secure"
"Clear"	"Social"
"Excited'	"Relaxed"
"Normal"	"Calm"
	"Friendly"
Myin-Germeys, et al., 2003; *(7-point Likert scale)*	
Negative affect	*Positive affect*
"Down"	"Happy"
"Guilty"	"Cheerful"
"Lonely"	"Satisfied"
"Anxious"	
"Angry"	
Kimhy et al., 2006; *(Visual Analog)*	
"I feel stressed"	
"I feel relaxed"	
"My thoughts are going too fast"	
"I feel sad/depressed"	
"I feel irritated'	
"I feel cheerful"	
"I feel lonely"	

Table 3
Examples of EMA Items used in the literature to assess situational context

Delespaul et al. 2002 *(Box Check)*	
Who am I with?	*What am I doing?*
"I am alone"	"Doing nothing"
"family "	"Self-care"
"friends"	"Work/study"
"colleagues "	"Leisure"
"strangers"	"Health-care"
	"Travel"
Granholm et al., 2008 *(Box Check)*	
Where are you right now?	
"In my home"	
"At home of relative or friend"	
"At work or in class"	
"Other Inside (store, office...)"	
Who is with you at this moment?	
"Any Outside (street, park)"	
"No one (you are alone)"	
"Family, friends, or partner"	
"Coworkers or classmates"	
"Strangers"	
"Other"	
What are you doing at this moment?	
"Inactive (TV, music, resting)"	
"Eating, dressing, hygiene care"	
"Shopping, chores, cooking"	
"Work, school, or active leasure"	
"Other"	

tions. The authors found that both dissociation and experiential avoidance had predictive effects; although only dissociation remained significant after controlling for other paranoia. Udachina et al. (2009) used paper and pencil EMAs to gather context and processes and a global self-report questionnaire to measure experiential avoidance (e.g., Bond et al., 2011). They found that individuals with high paranoia tended to experience poorer self-esteem, as well as higher experiential avoidance and depression. Finally, one study conducted by the first author of this chapter (RV), compared the relative effect of two distinct self-regulation strategies on quality of life in a sample of individuals with severe psychopathology (Vilardaga, Hayes, Atkins, Bresee, & Kambiz, 2013). In the following sections we will discuss this study with the aim of illustrating the use of EMAs in this population.

An EMA study comparing self-regulation strategies in severe psychopathology

Previous cognitive behavioral interventions for severe psychopathology have been tested and have demonstrated to have positive outcomes. Among them, Acceptance and Commitment Therapy (ACT; Hayes, Strosahl, & Wilson, 2011) reduced hospitalizations (Bach, Gaudiano, Hayes, & Herbert, 2012; Bach & Hayes, 2002), distress, affective symptoms and social impairment after discharge from an inpatient unit (Gaudiano & Herbert, 2006a). ACT-based interventions for psychosis also reduced mood symptoms and crisis contacts at follow-up (Gaudiano, Nowlan, Brown, Epstein-Lubow, & Miller, 2012; White, 2011). Traditional cognitive behavior therapy and ACT arguably target two different self-regulation strategies, cognitive reappraisal and psychological acceptance, respectively. Research shows that the impact of ACT on outcomes is mediated by reductions in levels of believability of psychotic symptoms (Gaudiano & Herbert, 2006b). Despite this, none of those studies conducted a more precise analysis of the interplay among specific contextual factors, individuals' responses to them, and the resulting outcomes.

Next, we will discuss the process of item development and selection of an EMA study in which we compared the role of psychological acceptance versus that of cognitive reappraisal with regards to quality of life in a sample of individuals with severe psychopathology. We will also conclude with some of the lessons learned while conducting this study. A more thorough discussion of the results is published elsewhere (Vilardaga et al., 2013).

Items adaptation and development. Keeping in mind the importance of theoretical coherence and design when conducting EMA research we discussed in previous sections, we examined the literature and selected items that addressed the contextual features, processes and outcomes of interest. For example, in order to assess situational factors we used items developed by Delespaul, deVries, and van Os (2002) and Granholm et al. (2008). These questions covered a number of situational factors that were important in order to understand daily patterns of responding, such as being alone or engaging in certain activities (see Table 3). In addition to situational factors we selected items to assess the occurrence of internal events, in this case psychotic experiences. Table 4 includes these items. These items were adapted from a previous study by Granholm et al. (2008), who, as opposed to previous researchers (see Table 1), developed items that covered the spectrum of psychotic experiences.

The items developed by Grandholm et al. (2008) were initially piloted in a small sample of individuals with severe psychopathology. Based on their feedback we decided to shorten their length, use more simple language and keep separate items for visual and auditory hallucinations.

This iterative process was achieved by using an open source software developed at the University of Washington called MyExperience (Froehlich, Chen, Consolvo, Harrison, & Landay, 2007). This software allowed the researcher to manipulate an internal .xml file (see Figure 1) to modify the items, the conditional rules to be implemented and other EMA features. This included the type of sound to we used to

```
<question id="8psychosis" text="Since the last survey, did any of the followi
  <property name="BackColor" value="White"/>
  <property name="ForeColor" value="Black"/>
  <property name="FontSize" value="9"/>
  <response widget="CheckBoxList">
    <options>
      <property name="OptionHeight" value="8"/>
      <option>I heard things that others could not hear</option>
      <option>I saw things that others could not see</option>
      <option>I felt that someone was spying or plotting against me</option>
      <option>I felt that people could read my thoughts</option>
      <option>I felt possessed or controlled by someone or something</option>
```

Figure 1. Example of .xml code from initial pilot versions.

signal surveys, the number of times it should be repeated or the length of time lapse until the next reminder. Before implementing this procedure with our final sample, it was tested by the first author of the chapter (R.V.), then by research assistants, and finally by a small sample of individuals with severe psychopathology.

To address psychological self-regulation strategies, we adapted items from existing global self-report measures. Our EMA design strategy was such that we programmed our devices so that when participants denied the occurrence of a psychotic or stressful event, they were presented directly with momentary quality of life items. This branching reduced assessment burden.[1] To select items addressing our targeted self-regulation strategies, we examined global self-report scales in the literature and picked specific items that had face validity and appropriate factor loadings. More specifically, to measure cognitive reappraisal, we picked item 6 from the cognitive reappraisal subscale of the Emotion Regulation Questionnaire (Gross & John, 2003). In order to measure cognitive suppression, we used item 7 from this very same questionnaire. Both items were slightly modified and adapted, a common practice in these type of studies (e.g., Hatzenbuehler, Nolen-Hoeksema, & Dovidio, 2009; Kashdan, Barrios, Forsyth, & Steger, 2006). To measure experiential acceptance, we picked item 2 from the Voices Acceptance and Action Scale (Farhall, Ratcliff, Shawyer, & Thomas, 2010; Shawyer et al., 2007). The last coping item from table 4 was designed to measure overt avoidance and we created it to fit the overall structure of the survey. Note that this particular item could have not been possible without a survey design that linked previous events (i.e., psychotic) to current response patterns. We randomized the order in which these items were presented to avoid priming effects. Although adding more items to assess each one of these processes (e.g., two items per process) would have allowed us to calculate an internal Cronbach's alpha, pilot testing indicated that this may have increased assessment burden. Thus, we chose to follow a single item approach and focus on improving the face validity of each item and its overall design fitness within the context of the overall survey.

The last part of the survey assessed moment-to-moment outcomes, in this case affect and quality of life. To asses current affect we adapted items from Myin-Germeys et al. (2003). Using a yes/no check box, we asked participants to rate which word was most representative of their feelings at that moment. Quality of life items were adapted from previous items of a quality of life scale specifically tailored to individuals with schizophrenia (Short Quality of Life Scale-18; Boyer et al., 2010). Each of these items targeted different dimensions of quality of life: anhedonia, self-esteem, perceived social support, autonomy and physical well-being. Since this was a central outcome in our study, we asked participants to rate each of these items on a 7-point Likert scale. A composite score of these items had a Cronbach's alpha of .81 in this sample.

Lessons learned. The study found that as opposed to cognitive reappraisal, experiential acceptance had a stronger association with a range of indicators of quality of life and functioning, suggesting that psychological acceptance might

[1]Of note, this strategy can potentially negatively reinforce skipping questions in future occasions. Researchers recommend having branching strategies that are balanced and offer equal amount of items.

Table 4
Sample of items from mindfulness and acceptance-based studies

Vilardaga et al. 2013; *Since the last survey did any of the following things happen to you?*; *(Box Check)*	
"I heard things that others could not hear"	"I saw things that others could not see"
"I felt that someone was spying or plotting against me"	"I felt that people could read my thoughts"
"I felt that someone could communicate with me through the TV/radio"	"None of the above"
"I felt possessed or controlled by someone or something"	
"I felt I had special powers to do something nobody else could do"	
"I felt stressed"	
Vilardaga et al. 2013; *How did you react?*; *(7-point Likert scale)*	
"I stopped doing the things I wanted to do" (External avoidance)	
"I tried to control my thoughts and feelings" (Suppression)	
"I made myself think about it in a way to make me stay calm" (Cognitive reappraisal)	
"I simply noticed my feelings and continued with what I was doing" (Experiential acceptance)	
Vilardaga et al. 2013; *Which emotion do you feel most strongly right now?*; *(Box Check)*	
"Down"	"Guilty"
"Relaxed"	"Anxious"
"Happy"	"Cheerful"
"Lonely"	"Satisfied"
"None of the above"	
Vilardaga et al. 2013; *How are you doing right now?*; *(7-point Likert scale)*	
"I enjoy what I'm doing" (Anhedonia)	"I feel competent" (Self-esteem)
"I feel connected to others" (Social support)	"I feel free to act" (Autonomy)
"I am comfortable with myself" (Self-esteem)	"I have energy" (Physical well-being)
Udachina et al., 2009, and Varese et al. 2011; *(7-point Likert scale)*	
"Since the last beep my emotions have got in the way of things which I wanted to do"	
"Since the last beep I've tried to avoid painful memories"	
"Since the last beep I've tried to block negative thoughts out of my mind"	

Note. Context items were omitted from this table but were adapted from Granholm et al., 2008. These Items can be found in Vilardaga et al., 2013.

be a psychologically "cost-effective" self-regulation strategy in this population when experiencing psychotic symptoms. Other situational factors, such as "doing something" also had a strong association with positive outcomes (Vilardaga et al., 2013). Using EMAs in this study not only allowed for comparison of specific psychological regulation strategies in the context of the daily life of individuals with severe psychopathology, but also a "real world" comparison of those processes using a measure of higher precision.

We also learned a few lessons. At a technical level, we learned that a small amount of software programming expertise can facilitate piloting and adapting EMA designs. In our case, this was achieved by using MyExperience (Froehlich et al., 2007). We did not keep track of the number of modifications we made to the myexperience.xml file, however, the number was very large. We would like to emphasize that it was critical to have the minimal software and technical skills required to make small code adjustments. Such a study would not have been feasible without the availability of this open source software, as the costs of a software programmer are often too great. Hiring an external programmer would also have limited the flexibility and speed of adaptations, which could have diminished the total number of iterations and the adequacy of the final procedure. However, this might not be an issue in funded studies. Some research centers in the country already have interdisciplinary teams of behavioral and computer scientists (e.g., *Center for Behavioral Intervention Technologies: CBITs*, 2013).

Second, we learned that hardware matters. In the above study, we trained participants in the use of the device. Following the initial training, we called participants on a daily basis to monitor technical problems with the device. In most occasions these calls were brief, but in some instances, it was required to coach the patient over the phone to recharge the device or to reset it. Other times, the researcher had to meet face-to-face with the participant and manually resolve the technical problem. As discussed by Kimhy et al. (2012), electronic EMAs pose new technical challenges. The Portable Digital Assistants (PDAs) that we used (Dell Axim X51) were brand new and had the appropriate hardware capacity to run our software. However, they initially presented with "odd behaviors;" for example, the device would turn off after a certain number of signals. We solved this problem after finding out that the type of audio file we were using to signal each survey was saturating the memory and forcing the machine to turn off. This issue was resolved by including an audio file of smaller size. Each mobile device will present specific software and hardware challenges, and it is very important to balance cost and potential technical difficulties when deciding between different devices. These decisions can have a serious impact on how the study is conducted and how participants respond to it.

Third, recruiting individuals with specific diagnostic categories to participate in EMA studies can be challenging. For example, in our study, there was a statistically significant difference between individuals with a diagnosis of schizophrenia as opposed to any other psychotic disorder (i.e., schizoaffective disorder, bipolar or depressive disorder with psychotic features). Participants with schizophrenia gave a number of reasons to refuse participation. Some simply indicated that they were not interested, others that they did not have the time. One person stated that the EMA device was intrusive to his privacy, and another indicated that he had serious concerns about the possibility of breaking it. These individuals were not thoroughly interviewed about their reasons for refusing, so we were unable to further explore their concerns about participation, but it is possible that because of these individuals' psychotic symptoms (delusions), they felt suspicious about the use of a mobile device. However, this calls for the implementation of a tailored recruitment strategy to approach individuals with schizophrenia versus other psychotic disorders, in which ample time is taken to reassure potential participant's concerns and thoroughly explain the use of the EMA device and its role in the study.

Finally, only three years after the study was finalized, mobile devices have evolved at such fast pace that we would not recommend the use of PDAs. These devices have frequent software "bugs," a weaker physical structure, shorter battery life and limited wireless connectivity. In contrast, current mobile devices (e.g., smartphones), are smaller, have more reliable software and greater capabilities (e.g., 4G, internet access). In addition, they are less intrusive as a research device as smartphones are nowadays an intrinsic part of human environments.

In the same way that introductory courses in chemistry include learning about the technical features of a microscope, if EMAs eventually become the "gold standard" in clinical behavioral science, we envision graduate student courses with a focus on basic programming skills and appropriate technical handling of mobile devices.

New opportunities, technologies and challenges

The use of contextual behavioral assessments, such as EMAs, in combination with the evolution of computerized mobile devices for commercial or leisure use, have created new opportunities for research and clinical practice in this population. These opportunities come with new challenges, such as the need to develop new strategies to "digest" large volumes of information to produce meaningful data. In the same way that over the decades a "symbiotic" relationship emerged between statisticians and clinical researchers, emerging mobile technologies call for a similar relationship between behavioral science and computer science. We have already mentioned some research laboratories where this interdisciplinary framework is already taking place (e.g., *CBITs*, 2013). In the following pages we will describe some of the opportunities, technologies and challenges of this new "wave" of clinical behavioral methods.

New Opportunities

Mobile technology adoption among individuals severe psychopathology. The first opportunity for treatment development and clinical care comes from the fact that an increasing number of people with severe psychopathology use mobile phones today. A recent survey among 1,592 individuals with a diagnosis of severe psychopathology reported that 72% of them had a mobile device, 33% of whom used it to access the internet and email (Ben-Zeev, 2012). The rate of adoption of mobile technology in this population, although lower than in the general population, will continue to rise (Ben-Zeev, 2012). Thus, mobile literacy will be present in the majority of young individuals as they develop a mental disorder (Ben-Zeev, 2012). As a result, the Center for Medicare and Medicaid is already expanding reimbursement procedures to include technologically-based services (Ben-Zeev, 2012).

The adoption of mobile technology by this population is not surprising, as there are already 6.8 billion mobile phones subscribers in the world (International Telecommunication Union, 2013), and it is expected that this number will increase exponentially in the following years. Moore's law stipulates that the number of transistors on a computer chip is expected to double approximately every two years (Moore, 1975). Consistent with this assertion, the capabilities and speed of mobile devices will continue to increase. As the availability of these devices rises and production costs shrink, they will become increasingly accessible and affordable to people with severe psychopathology.

Understanding mindfulness and acceptance processes with higher precision. Another opportunity presented by the use of contextual behavioral assessment methods is the possibility of exploring acceptance and mindfulness processes using a more contextual and precise method of assessment. Understanding processes and/or mechanisms of change has been a motif of recent emphasis in the cognitive behavior therapy literature (e.g., Kazdin, 2007). However, most processes of change have been examined using one-time global self-report measures. For this reason, these assessments rely on memory recall and are thus susceptible to retrospective bias. As mentioned in this chapter, retrospective bias is particularly problematic in this population.

The EMA method can accelerate our understanding of mindfulness and acceptance-based processes in both observational and experimental studies in a more precise and context specific fashion. For example, individuals' levels of mindfulness are often measured using global self-report measures that ask individuals to evaluate the degree to which they present with certain patterns of behaviors (e.g., "When I'm walking, I deliberately notice the sensations of my body moving"; Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006). These global mindfulness measures have improved our understanding of these processes, however, the advantage of EMAs is that researchers can evaluate the antecedents, self-regulation strategies and consequences of specific events. For example, in the study we described above, the assessment of psychological acceptance strategies (i.e., "I simply noticed my feelings and continued with what I was doing") was conducted only in the presence of a psychotic or stressful event (e.g. "I heard things that others could not hear"). Following that question, participants were asked about the emotional or functional consequences of such strategy (e.g., "I feel connected to others"). Similarly, EMAs could be used to examine statistical mediation (e.g., MacKinnon, Fairchild, & Fritz, 2007) of mindfulness and acceptance processes and help us understand the association between daily fluctuations of mindfulness during the course of treatment and their impact on outcomes. This can potentially improve our knowledge base about the specific strategies used by individuals diagnosed with severe psychopathology, and accelerate treatment development in this population. In addition to processes of change, EMAs can also be used to measure the outcomes of mindfulness and acceptance-based interventions. Such studies are starting to emerge in the literature (e.g., Geschwind, Peeters, Drukker, van Os, & Wichers, 2011; Nosen & Woody, 2013).

Improving interventions. Computerized EMAs and mobile devices can be used to improve the delivery of existing behavioral interventions. As mentioned earlier, mobile devices can be used to counterbalance the barriers posed by cognitive deficits in this population (Dickinson et al., 2004; Elvevåg & Goldberg, 2000; Harvey, 2010). These cognitive deficits have been shown to undermine treatment engagement (McKee, Hull, & Smith, 1997) and medication adherence (Jeste et al., 2003; Robinson et al., 2002). This is not surprising, as face-to-face interventions rely on individual's ability to describe their symptoms days or weeks later, remember long delayed appointments (sometimes every two months), or use behavioral skills when most needed (e.g., urges). In addition, these technologies can deliver behavioral interventions that are cost-effective, evidence-based, and tailored to each individual's needs (Choo, Ranney, Aggarwal, & Boudreaux, 2012). Mobile interventions can overcome these barriers by operating directly in the individual's environment with prompts to use skills, attend meetings, self-monitor habits and take medication. A thorough description of the use of these methods for intervention in this population is offered by Depp and colleagues (Depp, Mausbach, de Dios, Ceglowski, & Granholm, 2012; Depp et al., 2010), where they present data about the use of mobile technologies as a means to enhance existing interventions or deliver new treatments.

New technologies

The growth of mobile hardware (mobile devices) and software (apps), is so rapid, that an attempt to make a comprehensive review of existing devices and software platforms would be outdated by the minute. The growth of evidence-based apps, however, is rather anemic, and in no way parallel to the commercial development of these applications.

Mobile apps. Presently, there are countless smartphone apps to track mood and other psychological symptoms, representing a wide range of quality and sophistication. Apps with some level of empirical support include *BeWell*, and *Mobilyze!*. Although the focus of these apps is not on mindfulness and acceptance-based strategies, they still share a number of commonalities with ACT and other forms of cognitive behavior therapy. *BeWell* enables users to manage their physical well-being by monitoring physical activity, social interaction, and sleep patterns. The app then provides summaries of the effects of each these behaviors on well-being (Lane et al., 2012). *Mobilyze!* is a context-sensing app that predicts the user's mood based on phone sensors including GPS, ambient light, and recent calls. A corresponding website provides graphs correlating participant's self-reported mood states, and provides information on behavioral activation (Burns et al., 2011).

The *DBT Coach* is a mindfulness app that provides Dialectical Behavioral Therapy to help users identify emotions and associated action urges, determines if the user is interested in practicing mindfulness skills and suggests useful behaviors for the user to engage in (Rizvi, Dimeff, Skutch, Carroll, & Linehan, 2011). An example of non-empirically tested app is the *ACT Companion*, an app designed to facilitate the relationship between a patient and his or her ACT therapist (Berrick Psychology, n.d.). This app provides a range of well-crafted acceptance, mindfulness and commitment exercises that come with very useful follow up questions that can be readily shared by email with the therapist. *SmartQuit* is an ACT app designed to help individuals quit smoking. This app, developed by Jonathan Bricker, PhD., at the Fred Hutchinson Cancer Research Center, is currently being empirically in a pilot randomized controlled trial. In addition to these, there are other ACT apps designed to target specific ACT processes for the general public (e.g., Somatiq, n.d.).

In general, for mobile apps to be useful for clinical researchers and clinical practice, they need to be (a) highly customizable, and (b) include measurement of contextual antecedents and consequences of mindfulness and acceptance processes and practice. The majority of apps to date do not meet these requirements. Apps designed with this framework in mind would be more appealing to researchers and clinicians. Despite the fact that most apps lack those features, some mood tracking apps can be useful. One example is the *T2 Mood Tracker*, which was developed by The National Center for Telehealth and Technology (`http://t2health.org/`). This app can be used to track a variety of mood states and can be customized to some degree. We will refer to this app in a later section of this chapter. The T2 center has developed a number of mobile apps to improve psychological health of the US military community, however most of the apps can be used for a variety of clinical purposes in non-military populations.

Smartphone sensors. In addition to software, hardware innovation is bringing a wealth of new assessment possibilities for contextual behavioral research and clinical care. More specifically, new mobile devices are allowing the transition from self-reports to auto-reports. Self-reports require a conscious and deliberate effort to evaluate certain emotional, situational or behavioral state by part of the individual. However, auto-reports are the automatic collection of data by the mobile device itself through the use of mobile sensors. Although the internal context of the individual (e.g., emotional states) is subjective and not susceptible to automatization (e.g., physiological data is not equivalent to subjective emotional states), there are a number of situational and behavioral factors that can be measured with mobile sensors with higher precision than self-reports, such as motion and audio detectors and GPS tracking. To fully understand the role of mindfulness acceptance processes in relation to individual's functioning and response patterns, these features of the environment are important to take into account.

Furthermore, the interaction between self-reports and auto-reports can be used in the new field of machine learning (e.g., Burns et al., 2011), the next step in the development of treatments for this population. Machine learning will provide CBS researchers with tools to test specific behavioral learning hypotheses. For example, we can envision research studies in which the occurrence of a certain sequence of antecedents (e.g., three micro-episodes of delusional thinking) paired with physiological markers (e.g., heart rate variability), trigger prompts to use acceptance skills. This could be followed by a measurement of self-reported levels of well-being minutes or hours later, which would then be used to adjust machine learning algorithms that would inform future ratios of antecedents and skills prompts. Similarly, the amount of time dedicated on a weekly basis to formal mindfulness practice could be paired with daily EMA well-being ratings, and be used to inform the individual with personalized feedback about most useful levels of mindfulness practice. In other words, computer science offers great possibilities to enhance the testing of scientific hypotheses and the development of new mindfulness and acceptance-based interventions in this population.

New Challenges

These hardware and software developments will come with new challenges for behavioral scientists interested in the study of mindfulness and acceptance-based processes in this population. First, computerized EMAs can generate "Big Data." This term has been defined as "data of a very large size, typically to the extent that its manipulation and management present significant logistical challenges" (*Oxford English Dictionary*, 2013). Although the term Big Data is commonly used in fields such as computer technology and biomedical research, it certainly applies to data generated by ubiquitous information-sensing mobile devices, such as smartphones (e.g., Kumar et al., 2013). Despite the fact that there is some research using mobile sensors among adults with severe psychopathology (e.g., Kimhy, Sloan, et al., 2006), this technology will provide a wealth of data analytic challenges and considerations. These will require the need to use new statistical models for the analysis of intensive longitudinal data (Walls & Schafer, 2006), and adopt analytic tools with powerful visualization capabilities, such as the programming language R (R Core Team, 2013). Finally, the larger amounts of data provided by EMAs will allow mindfulness and acceptance-based researchers the implementation of single case design experiments (or ecological momentary experiments). This single case design approach is consistent with the inductive emphasis of the contextual behavioral science tradition (e.g., Barlow, Hayes, & Nelson, 1984; Vilardaga et al., 2009), which can be then combined with the use of randomization tests (e.g., Edgington & Onghena, 2007; Ferron & Ware, 1994), a statistical approach that does not make assumptions about the distribution of outcomes. In summary, a "truly" contextual behavioral study of mindfulness and acceptance-based processes in real time will involve addressing the large volumes of data generated by these technological innovations and using more sophisticated analytic tools to analyze them.

Insights from clinical practice

The current availability of mobile devices for an increasing proportion of individuals with severe psychopathology (Ben-Zeev, 2012) provides clinicians with exciting new opportunities to enhance their clinical practice with more contextually-based assessment methods. During the course of clinical practice, one author in this chapter (R.V.) provided therapy to an individual with a diagnosis of paranoid schizophrenia. This patient was in an advanced stage of recovery, and received a non-protocolized ACT intervention that covered all of the ACT components (Hayes et al., 2011). As part of an outpatient clinic, the patient was receiving case management and antipsychotic medication (intramuscular risperidone). The main treatment goal was to improve the patient's quality of life and provide further self-regulation skills to deal with residual psychotic symptoms. During the first two months, the patient completed weekly measures of quality of life as measured by the Short Quality of Life Scale-18 (Boyer et al., 2010). As a complement to these weekly overall ratings, we suggested the patient download the T2 Mood Tracker (National Center for Telehealth and Technology, 2013). This app has a number of predefined mood rating scales and offers the possibility of customizing alternative targets based on a specific case formulation. With our patient, we used two of the default categories to track anxiety and well-being. The patient was then instructed to complete momentary assessments twice a day for a period of approximately 1 month. These assessments were not randomly sampled throughout the day since the T2 Mood Tracker tool does not allow for random sampling of mood symptoms. Instead, they were scheduled at times in which they were less intrusive with the patient's daily activities: at the end of the morning and at the end of the evening. The quality of life scale and the EMA ratings did not target the exact same outcomes, however, there was some degree of overlap (e.g., feeling socially connected).

Figure 2 contains data for the global self-report measure. The chart presents data corresponding to the first month of treatment. We were not able to collect a baseline for this measure, however, note that the patient's levels of quality of life were very high throughout this period. This was consistent with the patient's life situation, level of functioning and clinical observation. Although the data from these global self-reports was clinically useful, this chart lacked the measurement precision to inform the patient's functioning and treatment.

The chart in Figure 3 represents data from the EMA reports during the first month, which corresponds to the same time period as the chart in Figure 2. Each dot in the chart corresponds to one momentary assessment of either well-being or anxiety. Well-being or anxiety was rated on a 0 to 100 visual analog scale. A score from 0 to 50 indicated a negative state (e.g., hopeless), whereas a score from 50 to 100 indicated a positive state (e.g., hopeful). Other examples of items included "unsafe" versus "safe," "angry" versus "content," "tired" versus "energetic," or "lonely" versus "connected." Thus, scores above 50 in the chart indicate well-being and lack of anxiety and scores below 50 indicate levels of anxiety and lack of well-being. The specific content of each one of those categories can be found in the app itself, which is freely available at (National Center for Telehealth and Technology, 2013).

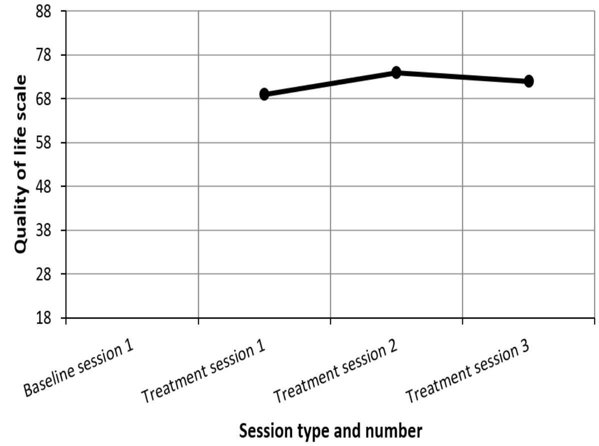

Figure 2. Total scores on the Short Quality of Life Questionnaire.

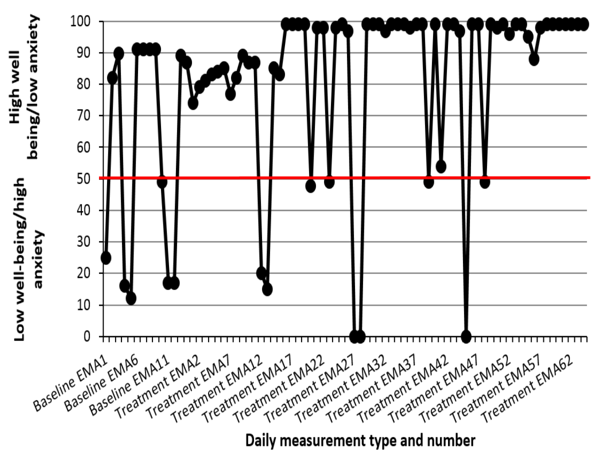

Figure 3. Daily EMA scores of positive affect (above 50), and negative affect (below 50), using the T2 Mood Tracker app.

First of all, the graph shows that consistent with global measures of quality of life, this patient had overall high levels of well-being and low levels of anxiety. Up until the fifteenth EMA, about half of the ratings were within the 50 to 90 range, and half within the 10 to 50 range. This pattern consistently changed afterwards. At this point, the patient started to report higher EMA ratings that topped 100, and a few instances in which the patient experienced very low levels of well-being and high levels of anxiety. Higher ratings in the global self-report scale were consistent with higher EMAs. However, at a clinical level, this fine-grained assessment of the patient's subjective experience of well-being allowed the discussion of specific daily situations, and the furthering of acceptance and commitment therapy self-regulation skills. Thanks to an EMA approach, what could have looked like an apparent lack of progress, turned out to be an obvious clinical improvement.

Conclusions

We hope this chapter provided the reader with a conceptual framework to understand the importance of contextual behavioral assessment methods as applied to the research and clinical care of individuals with psychosis, and the measurement of processes and outcomes of mindfulness and acceptance-based interventions. In the last decades, clinical behavioral science has made great advances in the understanding and treatment of severe psychopathology. However, in this chapter we argued that a "truly" contextual behavioral assessment approach (e.g., EMAs) will further advance the contextual behavioral etiology of psychosis and improve our mindfulness and acceptance-based interventions. EMAs are measurement tools that are consistent with the philosophical and theoretical assumptions of the CBS framework, and can provide the measurement and conceptual *precision* to evaluate the actual context in which individuals with severe psychopathology live their lives. Altogether, we believe that the challenges posed by a deeper access to the contextual factors influencing the lives of individuals with severe psychopathology will only strengthen the efficacy and effectiveness of clinical behavioral science in this population.

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